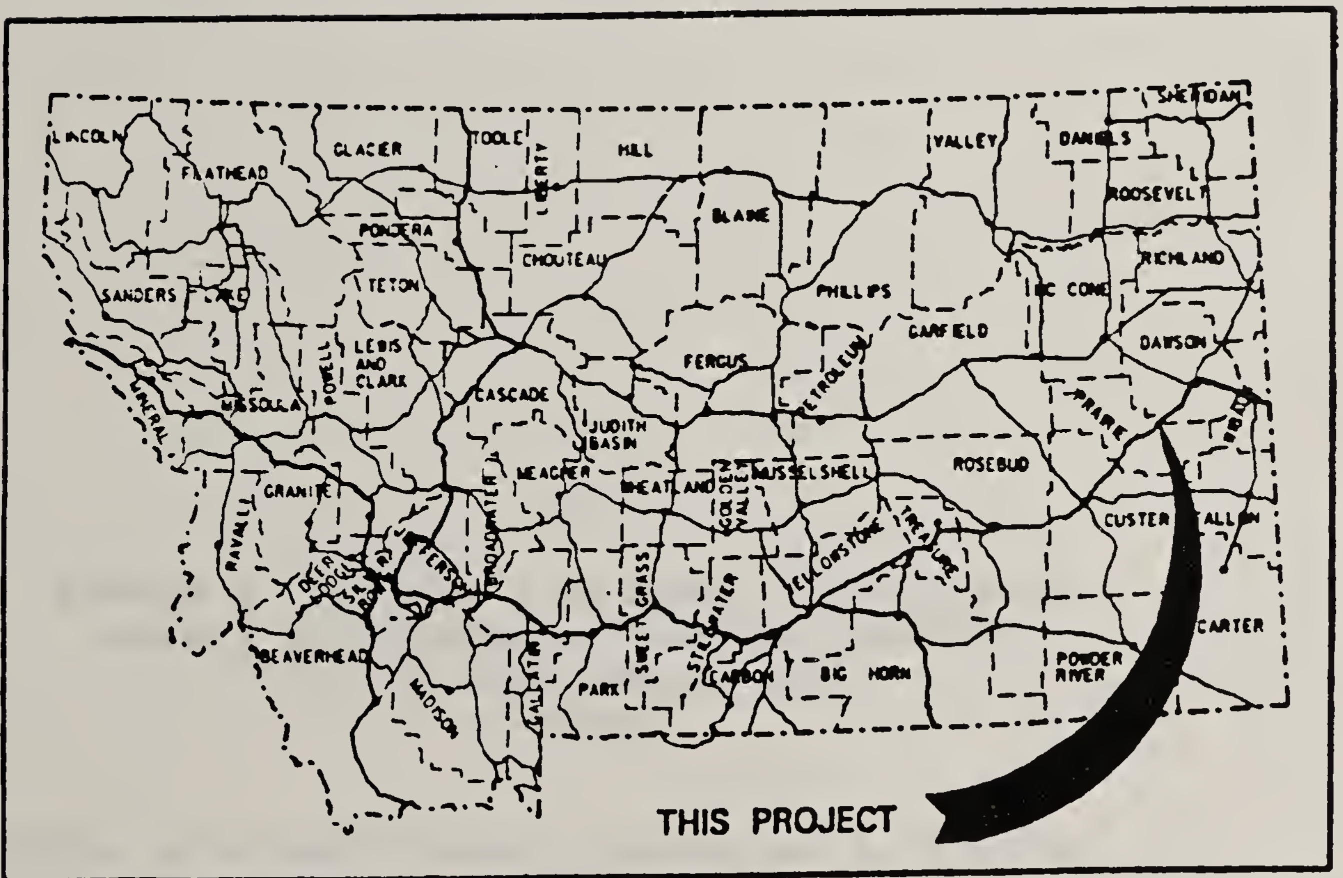
Field Experimental Project
Utilizing
Asphalt Modifiers

CONSTRUCTION
AND
POST CONSTRUCTION REPORT

November, 1991



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FEDERAL AID PROJECT NO. IR 94-5(25)185
PLANT MIX OVERLAY
PRAIRIE COUNTY LINE-WEST
PRAIRIE COUNTY, MONTANA

MONTANA DEPARTMENT OF TRANSPORTATION
in conjunction with the
FEDERAL HIGHWAY ADMINISTRATION

CONSTRUCTION AND POST CONSTRUCTION REPORT

by

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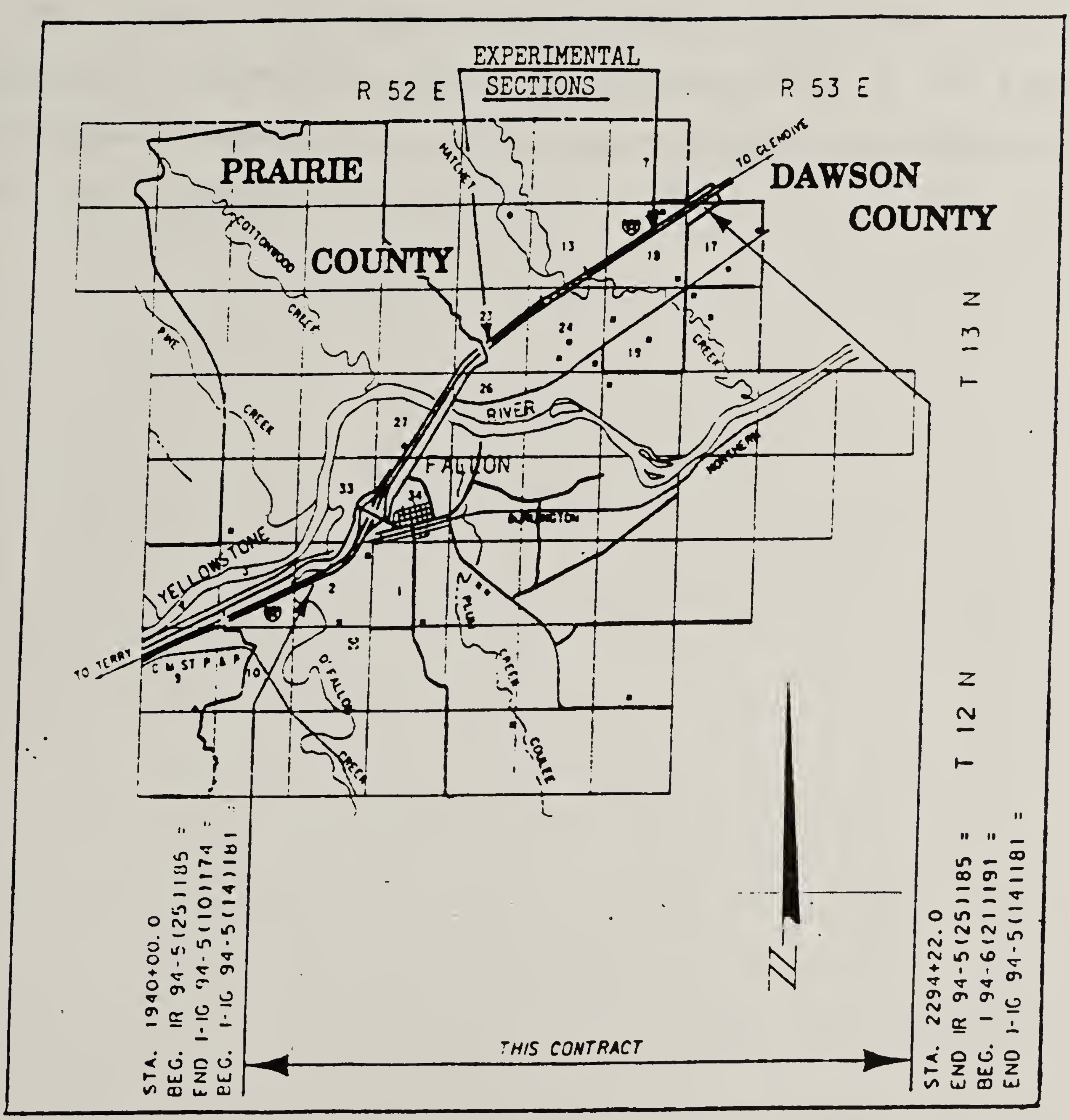
This is a draft report subjected to review, correction and/or modification

November, 1991



Station	**Mile Post**	
1940+00	184.5	Beginning of the Project
2126+92	188.0	Beginning of the Test Section
2174+73	188.9	Beginning of the Control Section
2204+73	189.5	End of the Control Section
2264+25	190.6	End of the Test Section
2294+22	191.2	End of the project

DISCLAIMER STATEMENT

The contents of this report reflect the views of the author who is responsible for the facts and accuracy of the data present herein. The contents do not necessarily reflect the official views or policies of Montana Department of Transportation or of the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

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Table of Contents

Description	Page
Introduction	1
Test Section	2
Transverse Profilograph Stations	7
Pavement Surface Condition	9
Rutting	18
Profilograph	18
Pre-construction Rut Measurement	19
Rut Depth	22
Transverse Pavement Profile	26
Overlay Construction	30
Materials	30
Aggregate	30
Asphalt	31
Kraton	32
Polybilt	32
Placement of Overlays	33
Field Testing	35
Core Density and Percent Air Voids	44
Cost Information	46
Post Construction Rut Measurement	46
Transverse Pavement Profile	50
Observation	51
Conclusion	53
Reference	56

List of Tables

Table	Description	Page
1	Stations, Length, and Sections by Asphalt Binders on East and West Bound I-94	5
2	Layout of MSU Stations for Transverse Profile Measurement Using Rainhart Profilograph, Location of Pins on the West Bound I-94	8
3	Layout of MSU Stations for Transverse Profile Measurement Using Rainhart Profilograph, Location of Pins on the East Bound I-94	10
4	Pavement Surface Condition - Transverse Cracks on West Bound Interstate I-94	11
4a	Total Number of Transverse Cracks and Severity Level on West Bound I-94	12
5	Pavement Surface Condition - Longitudinal Cracks on West Bound Interstate I-94	12
5a	Total Number of Longitudinal Cracks and Severity Level on West Bound I-94	12
6	Pavement Surface Condition - Transverse Cracks on East Bound Interstate I-94	14
6a	Total Number of Transverse Cracks and Severity Level on East Bound I-94	15
7	Pavement Surface Condition - Longitudinal Cracks on East Bound Interstate I-94	15
7a	Total Number of Longitudinal Cracks and Severity Level on East Bound I-94	15

List of Tables

Table	Description	Page
8	Summary of Statistical Analysis of Pavement Surface Condition of East and West Bound I-94	18
9	Pre-construction Rut Depth Obtained from Profilograph Results on West Bound I-94	23
10	Pre-construction Rut Depth Obtained from Profilograph Results on East Bound I-94	25
11	Aggregate Gradation	31
12	Bin Split Percentage	31
13	Data of Placement of Plant Mix Bituminous Surface-Grade B Asphalt Concrete on I-94	36
14	Daily Average of Marshall Stability and Flow, Unit Weight, and Percent Air Voids of the Marshall Specimen Made from the Plant Mix Bituminous Surface Grade B	38
15	Average Values of Mix and Asphalt Temperatures, Asphalt Percent, Stability, Flow, Unit Weight and Percent Air Voids	39
16	Quality Assurance Evaluation of Plant Mix Density	43
17	Density and Percent Air Voids of Pavement Cores	45
18	Post-Construction Rut Depth Obtained from Profilograph Results on West Bound I-94	48
19	Post-Construction Rut Depth Obtained from Profilograph Results on East Bound I-94	49

List of Figures

Figure	Description	Page
1	Layout of Test Section - Location of Kraton and Polybilt Modified Asphalt Sections, and Control Section	4
2	Typical Cross Section of Pavement in I-94	6
3	Severity Level of Transverse and Longitudinal Cracks on East and West Bound Interstate I-94	17
4	Profilograph Set up on the Pavement	21
5	Pre-construction Maximum and Average Rut Depth on Left and Right Wheel Paths of Driving and Passing Lanes of West Bound Interstate I-94	24
6	Pre-construction Maximum and Average Rut Depth on Left and Right Wheel Paths of Driving and Passing Lanes of East Bound Interstate I-94	27
7	Typical Pre-construction Pavement Profile and Elevation of a) Driving Lane and b) Passing Lane	29
8	Mix and Asphalt Temperatures of Plant Mix Bituminous Surface Grade B	37
9	Marshall Stability of Modified and Unmodified PMBS Grade B Specimens	41
10	Percent Air Voids of Modified and Unmodified PMBS Grade B Specimens	42
11	Typical Post-construction Pavement Profile and Elevation of a) Driving Lane and b) Passing Lane	52

List of Photos

Photo	Description	Page
A	Pre-construction Pavement Rutting and Bleeding	57
B	Full Width Transverse Thermal Crack with Crack Sealing	58
C	Two Distinct Phases of Pre-construction Driving and Passing Lanes of Pavement Surface with Apparent Maintenance Work on the Driving Lane	59
D	Position of the Steel Pins on Both Sides Pavement and Reference Bars by the Right-of-way Fence	60
E	Typical Transverse Crack	61
F	Typical Longitudinal Crack	62
G	Profilograph	63
H	Polybilt Tanker	63
I	Stationary Tank of Drum Type Continuous Bituminous Mix Plant	64
J	Drum Type Continuous Bituminous Mix Plant	64
K	Cold Milling Plant and Trenched Section	65
L	Dump Trucks and Paving Operation	66
M	Paver	66
N	Vibrating Rollers in Operation	67
O	Finishing Steel Wheel Roller	67
P	Post Construction Pavement Surface	68
Q	Bubbling of Polybilt and Kraton Polymer Modified Asphalt on the Break Down Roller Compacted Mat	68

Appendix

Appendix	Description
A -	Special Provision of the Contract Document - Specification and Requirement of the Construction of the Overlay on the Experimental Test Sections Using Modified Asphalt
B -	Project Proposal for Monitoring and Construction
C -	Tables 1A through 9A - Coordinate System of the Pre-construction Pavement Profile, an Output of Profilograph Record of West Bound Driving Lane
-	Tables 1B through 9B - Coordinate System of the Pre-construction Pavement Profile, an Output of Profilograph Record of West Bound Passing Lane
D -	Tables 10A through 18A - Coordinate System of the Pre-construction Pavement Profile, an Output of Profilograph Record of East Bound Driving Lane
-	Tables 10B through 18B - Coordinate System of the Pre-construction Pavement Profile, an Output of Profilograph Record of East Bound Passing Lane
E -	Tables 1C through 9C - Coordinate System of Pre-construction Pavement Profile Elevation of West Bound Driving Lane
-	Tables 1D through 9D - Coordinate System of Pre-construction Pavement Profile Elevation of West Bound Passing Lane

Appendix

Appendix		Description
F	-	Tables 10C through 18C - Coordinate System of Pre-construction Pavement Profile Elevation of East Bound Driving Lane
	-	Tables 10D through 18D - Coordinate System of Pre-construction Pavement Profile Elevation of East Bound Passing Lane
G	-	Figures 1A through 13A - Pre-construction Pavement Profile and Elevation of West Bound Driving Lane
	-	Figures 1B through 13B - Pre-construction Pavement Profile and Elevation of West Bound Passing Lane
H	-	Figures 14A through 26A - Pre-construction Pavement Profile and Elevation of East Bound Driving Lane
	-	Figures 14B through 26B - Pre-construction Pavement Profile and Elevation of East Bound Passing Lane
I	-	Tables 1E through 9E - Coordinate System of the Post-construction Pavement Profile, an Output of Profilograph Record of West Bound Driving Lane
	-	Tables 1F through 9F - Coordinate System of the Post-construction Pavement Profile, an Output of Profilograph Record of West Bound Passing Lane
J	-	Tables 10E through 18E - Coordinate System of the Post-construction Pavement Profile, an Output of Profilograph Record of East Bound Driving Lane

Appendix

Appendix		Description
J	-	Tables 10F through 18F - Coordinate System of the Post-construction Pavement Profile, an Output of Profilograph Record of East Bound Passing Lane
K	-	Tables 1G through 9G - Coordinate System of Post-construction Pavement Profile and Elevation of West Bound Driving Lane
	-	Tables 1H through 9H - Coordinate System of Post-construction Pavement Profile and Elevation of West Bound Passing Lane
L	-	Tables 10G through 18G - Coordinate System of Post-construction Pavement Profile and Elevation of East Bound Driving Lane
	-	Tables 10H through 18H - Coordinate System of Post-construction Pavement Profile and Elevation of East Bound Passing Lane
M	-	Figures 1C through 13C - Post-construction Pavement Profile and Elevation of West Bound Driving Lane
	-	Figures 1D through 13D - Post-construction Pavement Profile and Elevation of West Bound Passing Lane
N	-	Figures 14C through 26C - Post-construction Pavement Profile and Elevation of East Bound Driving Lane
	-	Figures 14D through 26D - Post-construction Pavement Profile and Elevation of East Bound Passing Lane

INTRODUCTION

In an effort to combat rutting problems in Montana, a laboratory test study on the effects of commercial modifiers on the physical properties of the Montana asphalts was conducted during 1988-89. As a result, two modifiers, Kraton D4141G from Shell Chemical Company, and Polybilt from Exxon were selected for further experimental field and laboratory studies. Both modifiers are rubber type polymers.

The field experimental study includes surveying of pre-construction pavement surface condition, recording construction activities, and monitoring post-construction pavement surface conditions. A Rainhart Transverse Profilograph was used for the surveying and monitoring of the pavement. The pre-construction pavement surface condition survey includes the selection of the profilograph test stations, profilograph data collection at those stations, and pavement surface cracks surveys. The construction activities consist of recording of the production of modified asphalts, asphalt-aggregate mix temperatures,and recording of placement and rolling performance of the mix. The special provision of contract document is included in Appendix A. The post-construction pavement surface condition monitoring consists of surveying the condition of the pavement, crack surveys, and collection of profilograph data of transverse profile of the pavement surface. The study proposal is shown in Appendix B.

The section of interstate highway I-94 was selected for the experimental test section and identified by Federal Aid Project

No. IR 94-5(25)185, Plant Mix Overlay, Prairie County Line-West Prairie County. The total length of the project was 6.7 miles, one half in the east bound lane and another half in the west bound lane. Each half section contains a section of Kraton D4141G modified asphalt, the control section, and a section of Polybilt modified asphalt.

TEST SECTION

The test section was selected in eastern Montana where the rutting problems are more severe. The test section is on Interstate Highway I-94, east of Billings near Fallon (west of Glendive). This region experiences the most diverse climatic conditions annually. The maximum temperature reported in 1990 was 105°F in August and the lowest temperature was -31°F in December. The average temperature of Glendive was 13.7°F in December and 73.6°F in August, 1990; and the average annual temperature was 46.9°F. The annual precipitation in 1990 was about 10 inches. The elevation of the area is about 2200 feet (Glendive is 2076 feet). (*1*)

The average daily traffic on I-94 was 3128 in 1990, out of which 628 were commercial vehicles. The total average daily traffic (ADT) consists of about 48 percent cars, about 27 percent pick ups, and 19 percent commercial vehicles. The percent of ADT taken over the months of June, July, and August was about 135 percent of ADT taken over the total year 1990. The temperatures were the highest in these months, averaging about 74°F. (*2, 3*)

The pavement surface in the test section was worn out. There were visible rutting, cracking, and bleeding (see Photo A). Most of the thermal transverse cracks ran the full width of the pavement. The crack maintenance was apparent from the sealed cracks (see Photo B). The pavement surface had two distinct appearances between the driving and passing lanes. The driving lane was black from recent maintenance activities, such as chip sealing and fine layer overlays to cover the original ruts in the original pavement surface (see Photo C). The surface was worn exposing coarse aggregates which were glossy in appearance and smooth to the touch. Most wheel paths on the driving lane were bleeding, and isolated patches of bleeding on the passing lane were noticed. During an observed rain, water ran in the ruts along the pavement surface in a longitudinal direction. Some water pools due to water logging were noticed along the pavement.

The test section consists of a length of about 3 miles on the east bound-lane and 3 miles on the west-bound lane of Interstate Highway I-94. The test section is a part of an overlay program of the Montana Department of Transportation. Table 1 shows the lengths and locations of the highway overlays by each of the modified asphalts and the control section for both east and west-bound lanes. The detail of the layout of the test section and location of sections with different binders are shown in Figure 1.

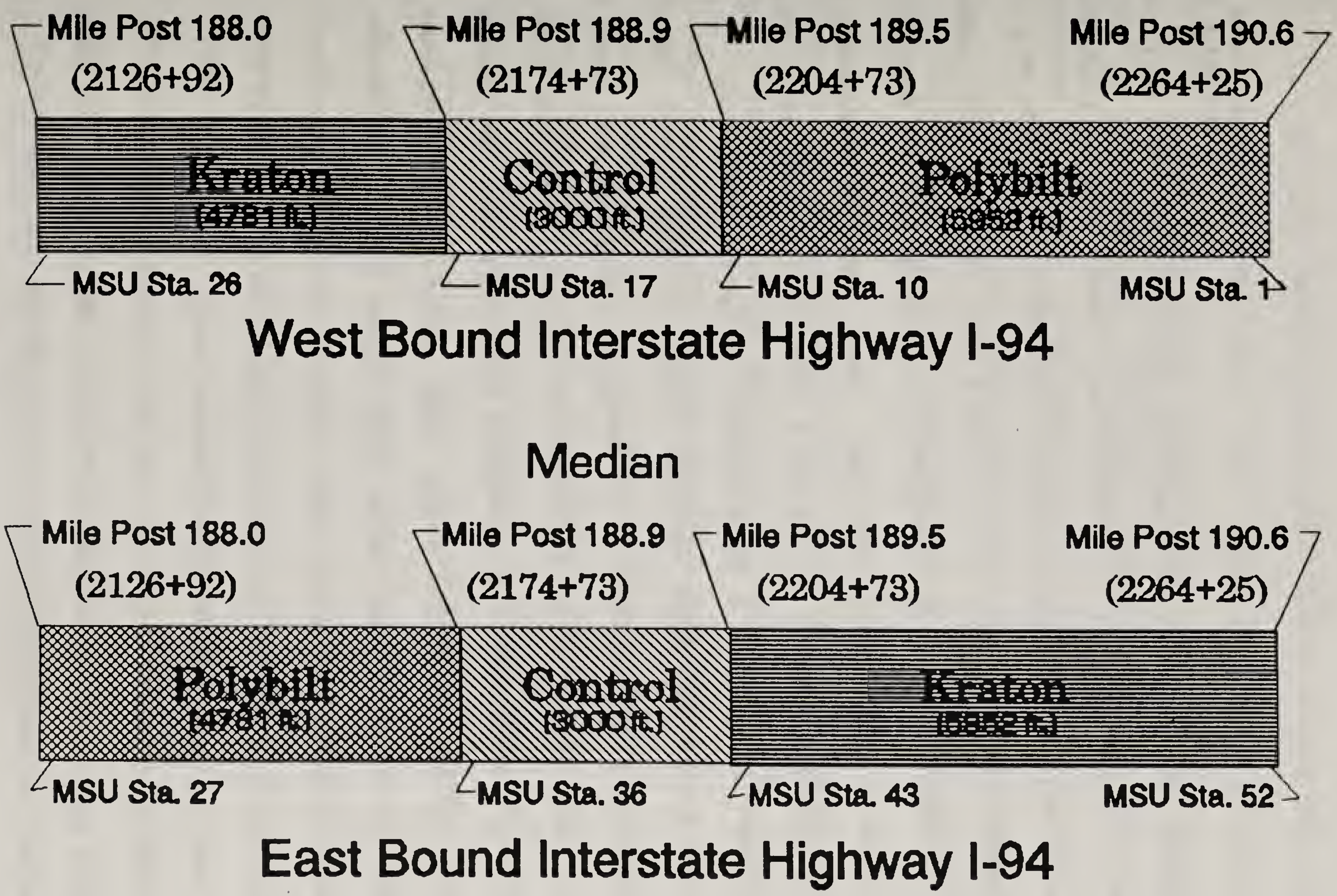


Fig. 1. Layout of Test Sections - Location of Kraton and Polybilt Modified Asphalt, and Control Section by the Mile Post, Station, and MSU Station Number.

Table 1. Station, Length, and Asphalt Binder on East and West Bound Lane

Station	Length (ft)	Binder on East Bound Lane	Binder on West Bound Lane
2126+92 to 2174+73	4781	Polybilt Modified Asphalt	Kraton Modified Asphalt
2174+73 to 2204+73	3000	85-100 Asphalt	85-100 Asphalt
2204+73 to 2264+25	5952	Kraton Modified Asphalt	Polybilt Modified Asphalt

The pavement overlay thickness consisted of 0.50 feet of plant mix bituminous base and 0.20 feet of plant mix bituminous surface(PMBS). A thickness of 0.20 feet of the driving lane was trenched by a milling machine and was back filled with the respective PMBS as the overlay material. A final overlay of 0.35 feet PMBS was then placed in two lifts. Figure 2 shows the typical cross section of the pavement.

STATE	PROJECT NUMBER	SHEET NO.
MONTANA	IR 94-5(25)185	3

LINEAR AND LEVEL DATA

LENGTH OF ROADWAY IR 94-5(25)185	34,177.85 FEET	=	6.473 MILES
LENGTH OF BRIDGES IR 94-5(25)185	1,398.95 FEET	=	0.265 MILES
TOTAL LENGTH OF IR 94-5(25)185	35,576.80 FEET	=	6.738 MILES

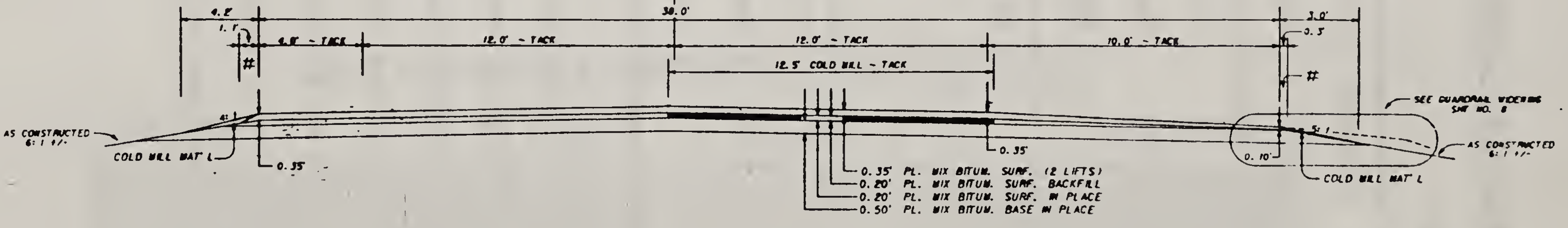
BEARING SOURCE

TAKEN FROM PROJECT: I - IG 94-5(14)181

TYPICAL SECTION NO. 1

STA. 1940+00.0 TO STA. 2294+22.0

EAST BOUND LANE REVERSE FOR WEST BOUND LANE



TEMPORARY 2:1 INSLOPE

NOTE: SEE SURFACING FRAME AND STRAIGHT LINE DETAIL FOR MODIFIED ASPHALT LOCATIONS

QUANTITIES											
UNIT	GRAVEL				UNIT	BITUMINOUS MATERIAL					
		PLANT MIX OVERLAY	PLANT MIX BACKFILL	△ COLD MILL MAT'L		TACK	PL. MIX OVERLAY OIL	PL. MIX BACKFILL OIL			
AREA SQUARE FEET		12.3	2.5	1.4	AREA SQUARE YARDS	983.3					
CU. YARDS PER STATION		45.6	9.3	5.2	TONS PER STATION		5.27	1.07			
TONS PER STATION		87.9	17.9	10.0	GALLONS PER STATION	49.2					

△ QUANTITY DOUBLED FOR INSLOPES

ZCAD(32,411220PCBL1.DGN

Figure 2. Typical Cross Section of Interstate Highway I-94 Pavement

TRANSVERSE PROFILOGRAPH STATIONS

The experimental test section was located with station markings at 200 foot intervals. Twenty-six profilograph stations were randomly selected in the total distance of 13733 feet on the west-bound lane of the test section. Steel pins, 1-inch in diameter, were driven into both sides of the west-bound lane, near the edge of the pavement to reference the transverse sections selected for profile study. The pins serve as the bench marks for differential leveling surveys. The pins are depressed about six inches beneath the shoulder surface to avoid disturbance. In addition, steel rebars were driven by the side of the right-of-way fence in a straight line from the steel pins. A general position of the steel pins and reference bars is shown in Photo D. The steel rebars were tagged with plastic identification labels, which indicated the station and an MSU number. The distance of the steel pins from the center line of the pavement and the distance of the steel bar from the closest pins were recorded. The whole process was recorded so that subsequent profilograph measurements can be conducted at the exact same location of the stations. The layout of the profilograph stations, location of pins and distance between them on the west-bound lane Interstate Highway I-94 are shown in Table 2.

Twenty six sections on the east-bound lane were selected at stations directly opposite the selected stations on the west bound lane. These stations were selected in this way for the ease of locating the stations in the future, and for cross checking

Table 2. Lay Out of MSU Stations for Transverse Profile Measurement Using Reinhart Profilograph, Location of Pins and Distance between Them on the West Bound Interstate Highway I-94

```
<--A-->  <-------- B  --------->  <----------C-- ---------->  <----D----->
X_______ X________________________ X______________________ X___________X
Rebar    Left        Driving   Pavement     Passing    Right      Median
         Pin         Lane      Center Line  Lane       Pin        Center Line
```

MSU Station Number	Highway Station	Distance Between: Rebar & Left Pin (ft) (A)	Left Pin and Center Line (ft.) (B)	Ct. Line & Right Pin (ft.) (C)	Rt. Pin & Med. Ct. Line (ft.) (D)	Lt. Pin & Right Pin (ft.) (B+C)	Remark
1	2260+00	51.54	28.48	21.68	30.04	50.16	51.72 (C+D)
2	2254+00	52.74	27.89	21.02	34.23	48.91	
3	2250+00	62.63	27.72	21.17	29.32	48.89	59.28 (Lt. Pin to Corner Post)
4	2244+00	70.81	27.92	21.29	29.06	49.21	
5	2238+00	81.18	27.71	20.79	29.73	48.50	
6	2232+00	80.74	27.76	21.53	29.55	49.29	
7	2226+00	80.62	27.11	21.49	28.87	48.60	
8	2220+00	80.82	27.45	21.20	30.55	48.65	
9	2214+00	79.92	27.91	21.42	27.34	49.33	
10	2208+00	68.37	30.45	21.95	26.08	52.40	Nail in paved median drainage
11	2200+00	66.52	31.29	21.77	25.75	53.06	
12	2196+00	66.70	31.05	22.21	27.45	53.26	
13	2192+00	NA	24.97	21.73	28.97	46.70	Guard rail face*
14	2188+00	NA	25.18	21.65	19.35	46.83	Nail in median, guard rail face*
15	2184+00	NA	25.31	21.65	23.25	46.96	Nail in median, guard rail face*
16	2180+00	71.28	28.68	21.54	24.88	50.22	Nail in paved median drainage
17	2176+00	68.50	31.46	21.30	25.81	52.76	Nail in paved median drainage
18	2170+00	72.95	27.79	21.12	28.42	48.91	
19	2164+00	93.95	30.53	22.05	32.12	52.58	
20	2160+00	85.58	27.83	22.22	29.67	50.05	40.00 (1st & 2nd Rebar Distance)**
21	2154+00	71.00	28.13	24.16	29.55	52.29	50.94 (1st & 2nd Rebar Distance)**
22	2150+00	65.65	27.17	23.67	26.05	50.84	54.87 (1st & 2nd Rebar Distance)**
23	2144+00	52.55	27.29	21.19	29.55	48.48	Nail in paved median drainage
24	2138+00	62.16	27.16	23.01	26.95	50.17	61.88 (1st & 2nd Rebar Distance)**
25	2134+00	82.92	27.62	21.31	28.30	48.93	44.33 (1st & 2nd Rebar Distance)**
26	2130+00	87.40	27.17	21.88	28.00	49.05	39.85 (1st & 2nd Rebar Distance)**

* Guard rail posts will be raised, therefore distances may be altered slightly.

** 1st rebar set at top of cut, 2nd rebar at right of way fence.

the levels of the pavement with reference to the steel pins. The steel pins were driven on the transverse section of both sides of the east-bound lane, as before. Reference bars were driven by the side of the right of way as explained before. MSU identification tags numbering from 27 to 52 were attached to the reference bars. The distance of each pin from the center of the pavement and from the closest pin to the reference bar were recorded. The MSU station number, highway station, the distances between the pins and center line of pavement and reference bar for the east-bound lane are tabulated as shown in Table 3.

PAVEMENT SURFACE CONDITION

Both the transverse and longitudinal cracks were studied with reference to the selected stations. Only cracks nearest to the station were recorded. The distance of the nearest crack from the station both ahead and behind the station were measured. The severity levels of the cracks were classified according to the SHRP distress identification manual for long term pavement performance studies (*4*). Photos of every crack were taken for record. The longitudinal cracks found in the vicinity of the station were also recorded according to the manual. Table 4 shows the severity levels of the transverse cracks on the pre-construction pavement surface and Table 4a shows the total number of transverse cracks and their severity levels for the west bound lane. Similarly, Tables 5 and 5a show the longitudinal cracks on the pavement and their severity levels for the west bound lane. Typical transverse and longitudinal cracks are shown in Photos E

Table 3. Lay Out of MSU Stations for Transverse Profile Measurement Using Reinhart Profilograph, Location of Pins and Distance between Them on the East Bound Interstate Highway I-94

```
<--A--> <------------- B----------> <------------ C -------> <----------D--------->
X_______ X____________________________ X____________________ X____________________X
Median   Left       Passing    Pavement   Driving    Right                  Rebar
Ct. Line Pin        Lane       Ct. Line   Lane       Pin                    Near
                                                                            Fence
```

MSU Station Number	Highway Station	Distance Between:					Remark
		Median Center & Left Pin (ft.) (A)	Left Pin & Center Line (ft.) (B)	Center Line & Right Pin (C)	Right Pin & Rebar (ft.) (D)	Left Pin & Right Pin (ft.) (B+C)	
27	2130+00	26.73	23.36	27.83	61.53	51.19	40.06´(1st & 2nd Rebar Distance)*
28	2134+00	27.87	22.64	23.68	NA	46.32	Guard rail face**
29	2138+00	27.92	22.13	24.98	NA	47.11	Guard rail face**
30	2144.00	26.48	21.91	27.33	100.01	49.24	Nail in paved median drainage
31	2150+00	28.79	21.44	27.72	70.15	49.16	Nail in paved median drainage
32	2154+00	23.29	23.42	26.71	71.10	50.13	Nail in paved median drainage
33	2160+00	26.33	22.02	29.48	68.83	51.50	
34	2164+00	24.23	22.15	28.52	99.00	50.67	
35	2170+00	29.32	21.33	27.26	100.70	48.59	
36	2176+00	30.88	22.07	30.39	92.25	52.46	
37	2180+00	29.04	24.54	30.11	67.22	54.65	
38	2184+00	31.06	23.89	24.38	NA	48.27	Guard rail face**
39	2188+00	23.82	23.88	25.52	NA	49.40	Guard rail face**
40	2192+00	26.16	24.21	28.21	NA	52.42	Guard rail face**
41	2196+00	25.82	24.55	27.04	NA	51.59	Guard rail face**
42	2200+00	28.26	24.23	24.19	NA	48.42	Guard rail face**
43	2208+00	27.68	24.93	30.19	67.65	55.12	Nail in paved median drainage
44	2214+00	27.24	23.88	29.12	69.62	53.00	Nail in paved median drainage
45	2220+00	24.13	24.12	30.35	67.93	54.47	
46	2226+00	26.43	23.62	27.85	70.42	51.47	
47	2232+00	26.02	21.98	29.46	66.83	51.44	
48	2238+00	26.55	22.82	27.64	70.21	50.46	
49	2244+00	26.43	23.41	28.13	70.14	51.54	
50	2250+00	27.28	22.10	27.55	70.42	49.65	
51	2254+00	21.33	23.51	28.32	68.87	51.83	
52	2260+00	24.95	23.13	30.27	66.79	53.40	

* 1st rebar set at top of cut, 2nd rebar at right of way fence.

** Guard rail posts will be raised, therefore distances may be altered slightly.

Table 4. Pavement Surface Condition - Transverse Cracks on West Bound Interstate Highway I-94

MSU Station	Station	Crack Type	Spacing of Cracks from the Station Ahead In ft.	Back in ft.	Crack Severity	Length of Crack	Remark
1	2260+00	Transverse	22.60		High	Full Width	
1	2260+00	Transverse		24.40	High	Full Width	
2	2254+00	Transverse	11.00		Moderate	Full Width	
2	2254+00	Transverse		28.50	Moderate	Full Width	
3	2250+00	Transverse	45.00		Moderate	Full Width	
3	2250+00	Transverse		22.20	High	Full Width	
4	2244+00	Transverse	27.50		High	Full Width	
4	2244+00	Transverse		9.00	High	Full Width	
5	2238+00	Transverse	63.27		High	Full Width	
5	2238+00	Transverse		22.20	High	Full Width	
6	2232+00	Transverse	39.60		High	Full Width	
6	2232+00	Transverse		15.60	High	Full Width	
7	2226+00	Transverse	36.60		Moderate	Full Width	
7	2226+00	Transverse		1.00	Moderate	Full Width	
8	2220+00	Transverse		16.50	Moderate	Full Width	
9	2214+00	Transverse	28.20		High	Full Width	
9	2214+00	Transverse		41.70	High	Full Width	
10	2208+00	Transverse	22.90		Low	Full Width	
10	2208+00	Transverse		10.80	Low	Full Width	
11	2200+00	Tranverse	9.00		High	Full Width	
11	2200+00	Transverse		14.00	High	Full Width	
11	2200+00	Transverse		20.00	High	Lt. Shoulder	
12	2196+00	Transverse	5.00		Moderate	Full Width	
12	2196+00	Transverse		18.90	High	Full Width	
13	2192+00	Transverse	16.00		Moderate	Full Width	
13	2192+00	Transverse		2.60	High	Full Width	
14	2188+00	Transverse	5.80		Moderate	Full Width	High Embankment
14	2188+00	Transverse		41.60	Moderate	Full Width	
15	2184+00	Transverse	13.40		Moderate	Full Width	
15	2184+00	Transverse		17.70	Moderate	Pass Lane	
16	2180+00	Tranverse	12.90		High	Full Width	Forked Crack
16	2180+00	Transverse		8.00	Moderate	Full Width	
17	2176+00	Transverse	20.00		Moderate	Full Width	
17	2176+00	Transverse		56.60	Moderate	Full Width	
18	2170+00	Transverse	29.00		High	Full Width	
18	2170+00	Transverse		39.00	High	Full Width	
18	2170+00	Transverse		22.00	Low	Shoulder	
19	2164+00	Transverse	7.60		High	Full Width	
19	2164+00	Transverse		30.90	High	Full Width	
20	2160+00	Transverse	23.10		Moderatre	Full width	
20	2160+00	Transverse		78.90	High	Full width	
21	2154+00	Transverse	61.20		High	Full Width	
21	2154+00	Tranverse		18.40	High	Full Width	
22	2150+00	Transverse	17.40		High	Full Width	
22	2150+00	Transverse		74.70	High	Full Width	
23	2144+00	Transverse	99.40		High	Full width	
23	2144+00	Transverse		24.40	High	Full width	
24	2138+00	Transverse	32.50		High	Full Width	
24	2138+00	Tranverse		2.30	High	Full Width	
25	2134+00	Transverse	8.30		High	Full Width	
25	2134+00	Transverse		52.80	High	Full Width	
26	2131+00	Transverse	20.40		Moderate	Full Width	
26	2131+00	Transverse		37.70	Moderate	Full Width	

Glendive Experimental Test Section, 1991

Table 4a. Total Number of Transverse Cracks and Their Severity Level on West Bound I-94

Total Number	Severity Level			Length of Cracks		
	High	Moderate	Low	Full Width	Shoulder	Passing Lane
53	32	18	3	50	2	1

Table 5. Pavement Surface Condition - Longitudinal Cracks on West Bound Interstate Highway I-94

MSU Station	Station	Crack Type	Spacing of Cracks from the Station		Crack Severity	Location of Crack	Length of Cracks (ft.)
			Ahead in ft.	Back in ft.			
10	2208+00	Longtidunal	0.00	27.00	High	Shoulder	27
15	2184+00	Longtidunal		3.00	High	Shoulder	25.4
17	2176+00	Longtidunal			High	Shoulder	Continuous
19	2164+00	Longtidunal		6.00	Moderate	Shoulder	52
19	2164+00	Longtidunal		6.00	Moderate	Cent. Line	31
24	2138+00	Longtidunal		7.00	High	Driving lane	38
25	2134+00	Longtidunal	57.00		Moderate	Cent. line	57 Ahead
25	2134+00	Longtidunal		54.00	Moderate	Cent. line	54 Back
26	2131+00	Longtidunal			Low	Cent. line	NA

Table 5a. Total Number of Longitudinal Cracks and Their Severity Level on West Bound I-94

Total Number	Severity Level			Length of Cracks		
	High	Moderate	Low	Driving Lane	Shoulder	Passing Lane
9	4	4	1	4	4	1

and F.

The following statistics were obtained from Table 4. On the average, there was a crack every 26.06 feet ahead of any station (with the standard deviation of 21.93 feet) and 25.08 feet in back of the station (with a standard deviation of 20.48 feet). In other words, the cracks were 51.14 feet apart from each other. Altogether, 53 transverse cracks were studied, out of which 60 percent were classified as high severity level, 34 percent were moderate severity level, and 6 percent of cracks were low severity level. Fifty of the 53 transverse cracks were full width pavement cracks including shoulders. Two cracks were on the driving lane only, and one crack was up to the passing lane. Altogether there were 10 longitudinal cracks in the west-bound lane, out of which 5 were of high severity level, 4 were of moderate level, and 1 was of low severity level. About 60 percent of the longitudinal cracks were shoulder cracks, and 40 percent were center line cracks and driving lane cracks. The bleeding on the wheel path was classified as low severity level.

Similarly, the distance of the nearest cracks, ahead and back of the selected stations on the east-bound lane were measured. Tables 6 and 6a show the transverse cracks and their severity level for the pre-construction pavement surface on the east-bound. On the average, there was a crack at every 30.48 feet with a standard deviation of 25.37 feet ahead of any section and at every 24.35 feet with a standard deviation of 19.07 feet in back of the station. In other words, on the average the cracks

Table 6. Pavement Surface Condition - Transverse Cracks on East Bound Interstate Highway I-94

MSU Station	Station	Crack Type	Spacing of Cracks from the Station Ahead in ft.	Back in ft.	Crack Severity	Length of Crack	Remarks
27	2130+00	Transverse	30.10		High	Full Width	
27	2130+00	Transverse		44.30	Moderate	Full Width	
28	2134+00	Tranverse	12.00		Moderate	Full Width	
28	2134+00	Transverse		33.60	Moderate	Full Width	Forked at shoulder
29	2138+00	Transverse	33.90		Low	Driving lane	
29	2138+00	Transverse		6.70	Moderate	Full with	
30	2144+00	Transverse	40.60		Moderate	Full with	
30	2144+00	Tranverse		51.30	Moderate	Full width	
31	2150+00	Transverse	16.20		Moderate	Full with	
31	2150+00	Transverse		25.40	Low	Driving lane	Raveling and Weathering
32	2154+00	Transverse	84.90		Low	Driving lane	
32	2154+00	Transverse		25.40	High	Full width	
33	2160+00	Transverse	27.90		High	Driving lane	
33	2160+00	Transverse		25.80	High	Full width	
34	2164+00	Transverse	0.00		Moderate	Full width	
34	2164+00	Transverse		22.80	Moderate	Full width	
34	2164+00	Transverse		25.00	Moderate	Full width	
35	2170+00	Transverse	70.40		High	Full width	Visual Ruts
35	2170+00	Transverse		60.80	Moderate	Full width	
36	2176+00	Transverse	22.60		Moderate	Full width	Visual Ruts
36	2176+00	Transverse		39.20	Moderate	Full width	
37	2180+00	Transverse	27.90		High	Full width	
37	2180+00	Transverse		7.50	Moderate	Full width	Rutting and Bleeding
38	2184+00	Transverse	32.20		Moderate	Full width	
38	2184+00	Transverse		13.10	Low	Driving lane	Visual Ruts
39	2188+00	Transverse	22.70		Low	Driving lane	Visual Ruts
39	2188+00	Transverse		22.90	High	Full width	
40	2192+00	Transverse	20.30		Low	Driving lane	1/8 of driving lane
40	2192+00	Transverse		3.90	High	Full width	
41	2196+00	Transverse	9.10		Moderate	Full width	
41	2196+00	Transverse		22.00	Low	Driving lane	9/10 of driving Lane
42	2200+00	Transverse	34.00		Moderate	Full width	
42	2200+00	Transverse		33.20	High	Full width	Rutting and Bleeding
43	2208+00	Transverse	39.30		Moderate	Full width	
43	2208+00	Transverse		15.80	Low	Driving lane	Visual Ruts
44	2214+00	Transverse	17.70		Moderate	Full width	
44	2214+00	Transverse		1.00	High	Full width	Rutting and Bleeding
45	2220+00	Transverse	7.80		Moderate	Full width	Rutting and Bleeding
45	2220+00	Transverse		63.30	Low	Full width	
46	2226+00	Transverse	11.40		High	Full width	
46	2226+00	Transverse		22.40	High	Full width	Rutting and Bleeding
47	2232+00	Transverse	21.00		Low	Full width	
47	2232+00	Transverse		4.70	High	Full width	
48	2238+00	Transverse	3.00		High	Full width	
48	2238+00	Transverse		57.70	Low	Full width	
49	2244+00	Transverse	75.40		Moderate	Full width	Rutting and Bleeding
49	2244+00	Transverse		50.40	High	Full width	
50	2250+00	Transverse	100.00		Moderate	Full width	
50	2250+00	Transverse		10.10	Moderate	Full width	
51	2254+00	Transverse	16.80		Moderate	Driving lane	
51	2254+00	Transverse		10.80	Moderate	Full width	
52	2260+00	Transverse	15.40		Moderate	Full width	
52	2260+00	Transverse		7.10	Low	Driving lane	

Table 6a. Total Number of Transverse Cracks and Their Severity Level on East Bound I-94

Total Number	Severity Level			Length of Cracks		
	High	Moderate	Low	Full Width	Shoulder	Driving Lane
53	15	26	12	42		11

Table 7. Pavement Surface Condition - Longitudinal Cracks on East Bound Interstate Highway I-94

MSU Station	Station	Crack Type	Spacing of Cracks from the Station		Crack Severity	Location of Crack	Length of Cracks (ft.)
			Ahead in ft.	Back in ft.			
27	2130+00	Longtidunal		15.30	Moderate	Shoulder	23.6
28	2134+00	Longtidunal	12.00		Moderate	Shoulder	56.8
30	2144+00	Longtidunal			High	Shoulder	Continuous
34	2164+00	Longtidunal			Low	Shoulder	Continuous
51	2254+00	Longtidunal		16.80	Moderate	Passing lane	47.8
52	2260+00	Longtidunal	15.40		Moderate	Center line	52

Table 7a. Total Number of Longitudinal Cracks and Their Severity Level on East Bound I-94

Total Number	Severity Level			Length of Cracks		
	High	Moderate	Low	Driving Lane	Shoulder	Passing Lane
6	1	4	1	1	4	1

were 54.8 feet apart from each other. Altogether 53 transverse cracks were measured in 26 sections, out of which 28 percent were of high severity level, 49 percent of moderate severity level, and 23 percent were of low severity level. Most of the transverse cracks were of full-width pavement including the shoulders on both sides. Forty-two cracks, that is 79 percent of transverse cracks, were full-width pavement cracks and 21 percent were limited to the shoulder and driving lane only. Only 6 longitudinal cracks in the proximity of the selected sections were measured; four of these were shoulder cracks, one on the center line of the pavement, and one on the passing lane. Tables 7 and 7a show the longitudinal cracks of the pre-construction pavement and their severity level on the east bound lane. The length of the longitudinal cracks are also shown in Table 7. Again, of 6 longitudinal cracks 4 were classified as moderate severity level, 1 high severity, and 1 low severity level. In comparing the pavement surface conditions between the east-bound lane and west-bound lane, it was found that the east-bound lane was less severe than the west-bound lane. Figure 3 shows the severity level of the transverse and longitudinal cracks on east and west bound Interstate Highway I-94. Table 8 shows the comparison of the pavement surface conditions on the west-bound lane and the east-bound lane.

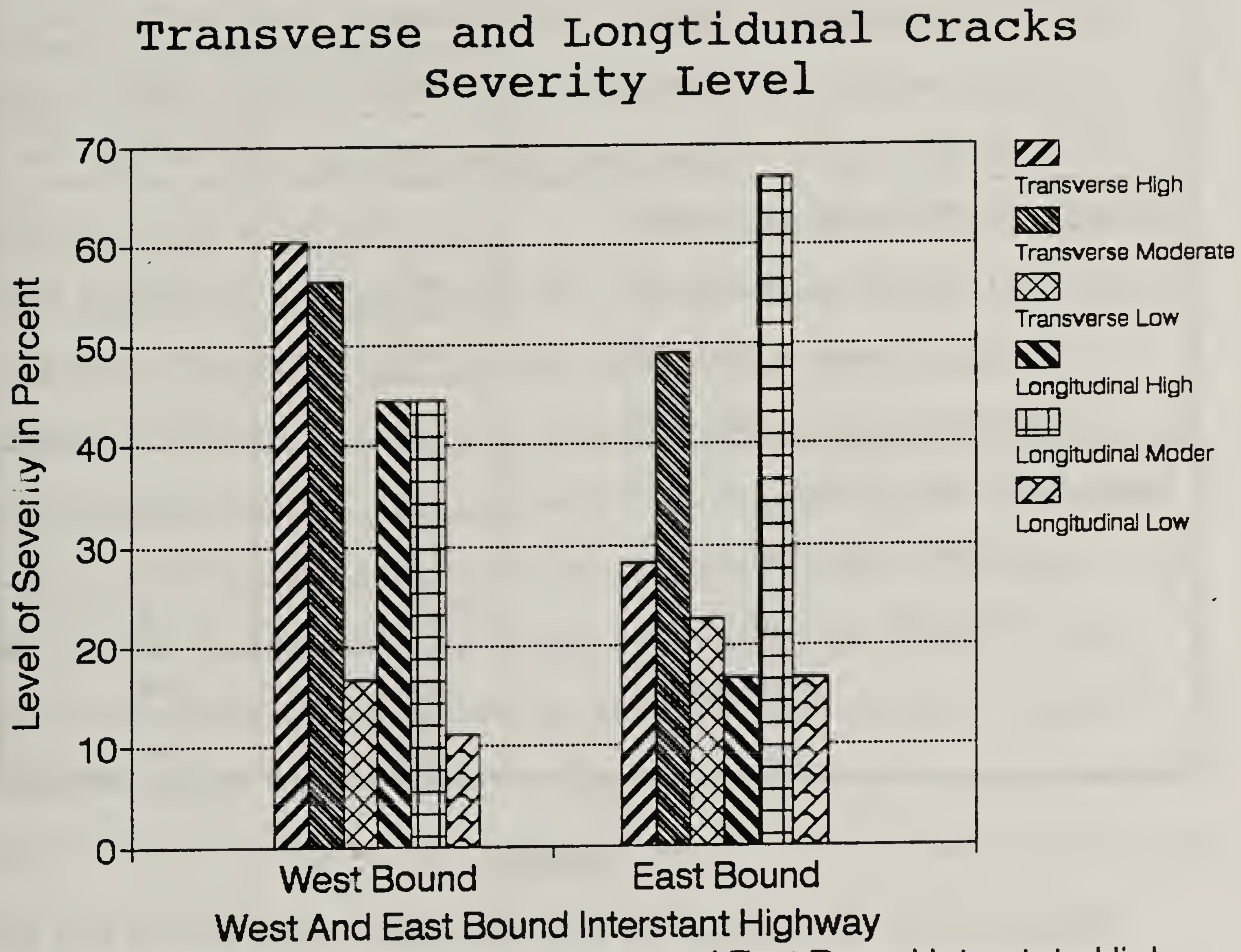


Figure 3. Severity Level of Cracks on West and East Bound Interstate Highway I-94

Table 8. Pavement Surface Condition of West and East Bound I-94

Description	East Bound Lane	West Bound Lane
Transverse Cracks		
Average Distance Between Cracks	54.8 ft.	51.1 ft.
Severity: High	28%	60%
Moderate	49%	34%
Low	23%	6%
Length of Transverse Cracks		
Full Width + Shoulder	79%	94%
Driving Lane + Shoulder	21%	4%
Passing Lane + Shoulder		2%
Longitudinal Cracks		
Number Counted	6	9
Severity: High	50%	44%
Moderate	40%	44%
Low	10%	12%

RUTTING

Rutting is described in the Distress Identification Manual, (*4*) as longitudinal surface depression in the wheel path. Severity level is not applicable. However, severity levels can be defined in relation to inches of rut depth. Rut depths are measured in inches to the nearest 1/10-inch at 50 ft. intervals for each wheel path.

Profilograph

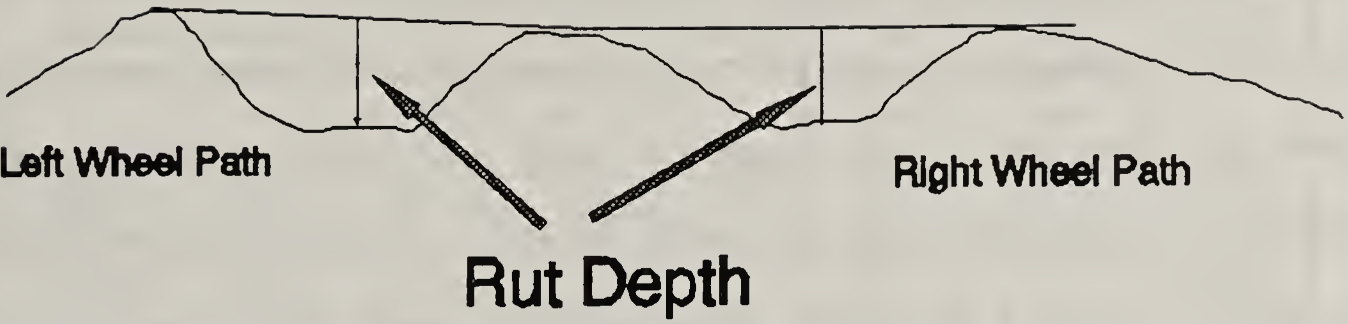
The profile of the pavement was taken at each identified station and the rut depth of the pavement was measured. The vertical pavement profiles, for this project were measured using a Rainhart Transverse Profilograph (see Photo G). This profilograph produced a record of the transverse profile of pavements; its chart displayed the cross section surface profile, wheel path ruts, and surface imperfections. The profilograph provides a continuous measurement of the rut across the entire width of the profilograph, approximately 13 feet transverse to the direction of traffic.

The Rainhart transverse profilograph consists of a diamond shaped beam, approximately 14 feet in length which allows measurements across a lane via a rotating recording cylinder-pen apparatus that follows the rut vertical displacement. The beam spans the rutting transversely and is positioned well above the highest point of the ruts by means of supporting feet on the bottom of the beam. A rotating cylinder, actuated by a cable on the beam, carries a pen that scribes the transverse profile of the ruts as the cylinder is manually moved on the beam across the ruts. A profilograph record is produced on an 8.5 by 17-inch sheet of graph paper wrapped around the drum. The vertical pavement profile is recorded in a 1:1 scale, while the horizontal scale measures the width of pavement at a scale of 1:12 (one inch on the chart represents one foot on the pavement).

Pre-construction Rut Measurement

The pre-construction profilograph records were taken during the survey from March 22 to March 28, 1991. A highway lane, driving or passing, was blocked to provide adequate protection for both the instrument and crew. The test section was swept so that loose gravel was not recorded. At the beginning of each recording, the profilograph beam was placed across the lane in such a way that the tracing wheel was set above the mark on the center line of the pavement transverse to the selected station. The mark on the center line was in a straight line with the station steel pins on the side of the pavement. The setup is shown in Figure 4. A fresh recording chart was clamped on the drum, and the felt pen was set at the beginning of the chart. The sensing wheel was lowered on the pavement. The pavement profile was recorded by rolling the drum recorder manually across the beam. The pavement profile was retraced on the return run of the drum about an inch lower to the first one. The station number, station, lane identification and date were recorded for identification of the profile. The process was repeated on the driving and passing lane of both east and west-bound lanes.

The results of the differential leveling survey were recorded in the field book. The position of the profilograph legs on the pavement surface were marked. The levels of the position of the profilograph legs, the steel pins on both sides of the pavement, reference steel bar by the right-of-way fence, and the pin across the median on the opposite bound lane were each recorded. The profilograph was not horizontal; the slope of the profilograph was parallel to the slope of the line between the position of the profilograph legs on the pavement. The exact profile of the pavement surface including the transverse slope



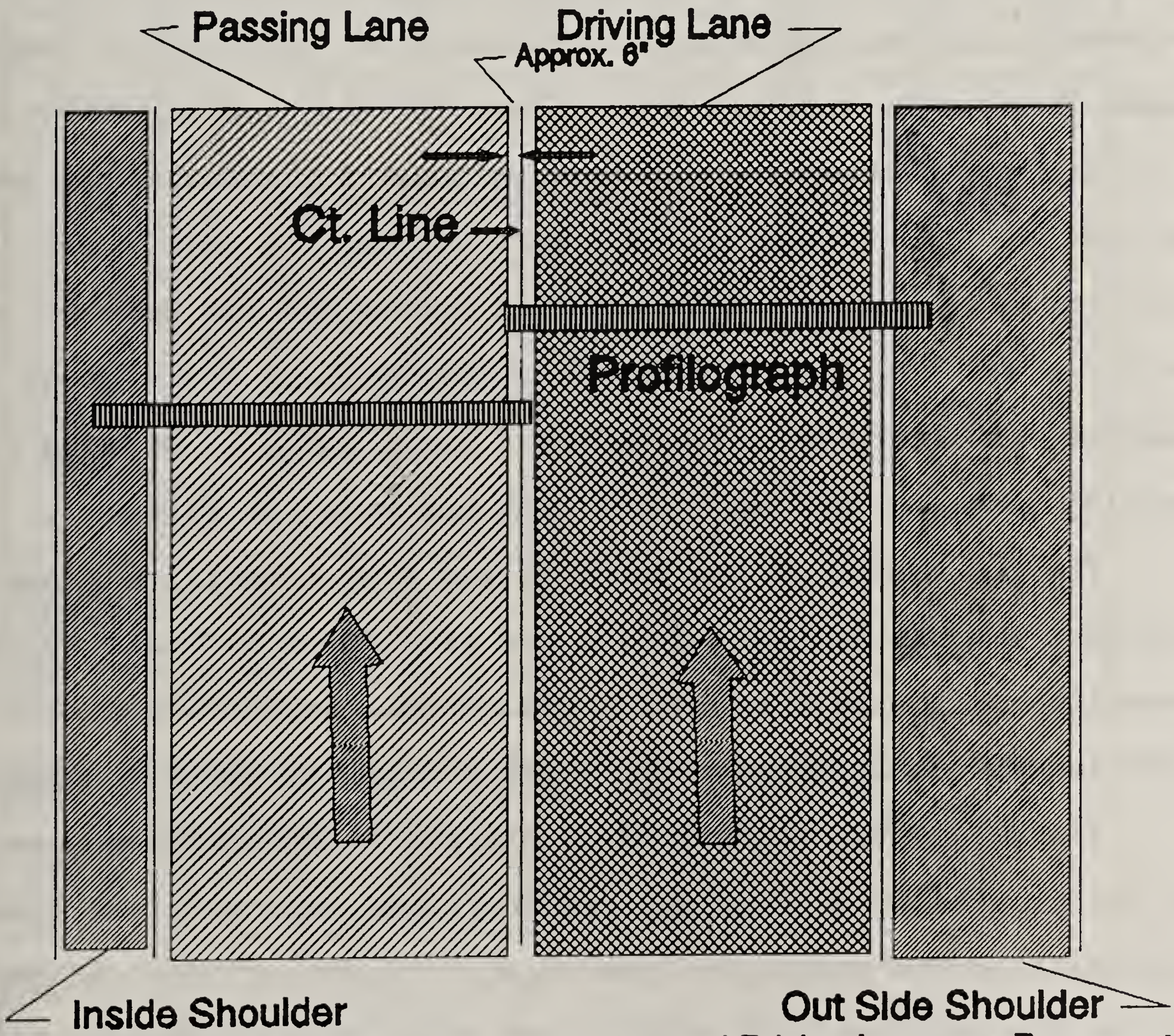


Figure 4. Profilograph Set Up on Passing and Driving Lanes on Pavement

was drawn with these data.

Rut Depth

The maximum rut depths at each of the wheel paths for driving and passing lanes on the west-bound lane were measured from the transverse profilograph record at each section. Table 9 shows the rut depth on each of left and right wheel paths of the west-bound driving and passing lanes. It was observed that the rut depth on the driving lane was greater than that in the passing lane, even though the driving lane had undergone several maintenance activities to cover the rutting on the original pavement surface. The average rut depths on the left and right wheel paths were 0.26 and 0.18 inches for the passing lane, and 0.31 and 0.29 inches for the driving lane. The maximum rut depths on left and right wheel paths were 0.45 and 0.55 inches for the driving lane, and were 0.55 and 0.45 inches for the passing lane, as shown in Table 9. The relative differences of the average and maximum rut depths on left and right wheel paths of driving and passing lanes of the west bound lane are shown in Figure 5.

The rut depths of the Polybilt and Kraton modified asphalt sections and the control section are also shown in Table 9. This base information will be useful for future comparisons to profilograph rut measurements, which will be surveyed annually.

Similarly, the rut depths of the pre-construction pavement on the east bound driving and passing lanes were obtained from the profilograph output and are shown in Table 10. The rut depths on the driving lane were higher than those on the passing lane

Table 9. Pre-construction Rut Depth from Profilograph Results on West Bound Interstate Highway I-94.

MSU Station Number	Highway Station	Section by Binder Used	West Bound Passing Lane (WBPL)			West Bound Driving Lane (WBDL)		
			Left Wheel Path (LWP) (in)	Right Wheel Path (RWP) (in)	Center (in)	Left Wheel Path (LWP) (in)	Right Wheel Path (RWP) (in)	Center (in)
1	2260+00	Polybilt	0.30	0.20	0.00	0.35	0.45	0.30
2	2254+00	Polybilt	0.35	0.55	0.00	0.55	0.30	0.25
3	2250+00	Polybilt	0.45	0.35	0.00	0.55	0.25	0.25
4	2244+00	Polybilt	0.20	0.15	0.00	0.55	0.45	0.00
5	2238+00	Polybilt	0.30	0.20	0.00	0.30	0.35	0.30
6	2232+00	Polybilt	0.30	0.20	0.00	0.55	0.35	0.00
7	2226+00	Polybilt	0.40	0.35	0.00	0.30	0.20	0.00
8	2220+00	Polybilt	0.35	0.15	0.00	0.30	0.30	0.00
9	2214+00	Polybilt	0.30	0.20	0.00	0.10	0.40	0.20
10	2208+00	Polybilt	0.25	0.15	0.00	0.20	0.30	0.20
11	2200+00	Exxon	0.20	0.10	0.00	0.25	0.25	0.20
12	2196+00	Exxon	0.25	0.15	0.00	0.35	0.40	0.20
13	2192+00	Exxon	0.33	0.15	0.00	0.30	0.30	0.20
14	2188+00	Exxon	0.25	0.13	0.00	0.20	0.15	0.10
15	2184+00	Exxon	0.30	0.20	0.00	0.25	0.30	0.20
16	2180+00	Exxon	0.30	0.20	0.00	0.25	0.30	0.20
17	2176+00	Exxon	0.20	0.20	0.00	0.25	0.25	0.00
18	2170+00	Kraton	0.30	0.20	0.00	0.20	0.20	0.25
19	2164+00	Kraton	0.20	0.15	0.00	0.35	0.15	0.00
20	2160+00	Kraton	0.20	0.15	0.00	0.30	0.30	0.00
21	2154+00	Kraton	0.20	0.10	0.00	0.30	0.30	0.00
22	2150+00	Kraton	0.20	0.10	0.00	0.30	0.20	0.00
23	2144+00	Kraton	0.20	0.15	0.00	0.20	0.25	0.00
24	2138+00	Kraton	0.15	0.05	0.00	0.30	0.20	0.00
25	2134+00	Kraton	0.20	0.10	0.00	0.30	0.30	0.00
26	2130+00	Kraton	0.20	0.10	0.00	0.25	0.25	0.00

Overall Average Rut Depth	0.26	0.18	0.00	0.31	0.29	0.11
Overall Standard Deviation	0.07	0.10	0.00	0.12	0.08	0.12
Overall Maximum Rut Depth	0.45	0.55	0.00	0.55	0.45	0.30
Overall Minimum Rut Depth	0.15	0.05	0.00	0.10	0.15	0.00

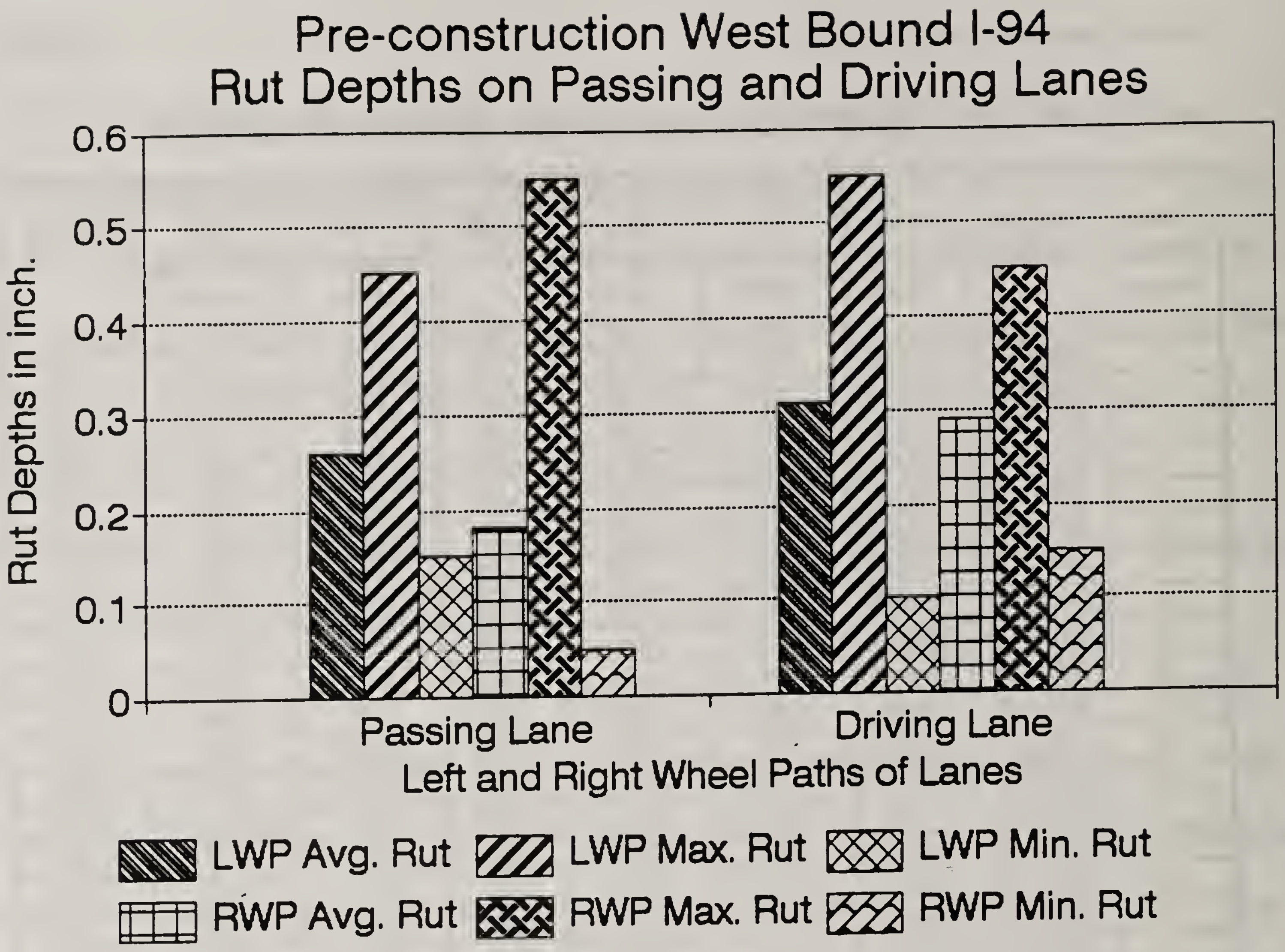
Statistics of Rut Depth by Proposed Section for Modified Binder on West Bound Passing and Driving Lanes

Statistics of Rut Depth on LHWP of WBPL			
	Average	Maximum	Minimum
Polybilt	0.32	0.45	0.20
Kraton	0.21	0.30	0.15
Exxon	0.26	0.33	0.20

Statistics of Rut Depth on RHWP of WBPL			
	Average	Maximum	Minimum
Polybilt	0.25	0.55	0.15
Kraton	0.12	0.20	0.05
Exxon	0.16	0.20	0.10

Statistics of Rut Depth on LHWP of WBDL			
	Average	Maximum	Minimum
Polybilt	0.38	0.55	0.10
Kraton	0.28	0.35	0.20
Exxon	0.26	0.35	0.20

Statistics of Rut Depth on RHWP of WBDL			
	Average	Maximum	Minimum
Polybilt	0.34	0.45	0.20
Kraton	0.24	0.30	0.15
Exxon	0.28	0.40	0.15



Note: LWP - Left Wheel Path, RWP - Right Wheel Path

Fig. 5. Average, Maximum, and Minimum Rut Depths on Passing and Driving Lanes

Table 10. Pre-construction Rut Depth from Profilograph Results on East Bound Interstate Highway I-94

MSU Station Number	Highway Stations	Section by Binder Used	East Bound Passing Lane (EBPL)			East Bound Driving Lane (EBDL)		
			Left Wheel Path (LWP) (in)	Right Wheel Path (RWP) (in)	Center (in)	Left Wheel Path (LWP) (in)	Right Wheel Path (RWP) (in)	Center (in)
27	2130+00	Polybilt	0.20	0.15	0.00	0.20	0.30	0.20
28	2134+00	Polybilt	0.25	0.10	0.00	0.40	0.20	0.20
29	2138+00	Polybilt	0.30	0.10	0.00	0.35	0.20	0.10
30	2144+00	Polybilt	0.25	0.10	0.00	0.50	0.55	0.10
31	2150+00	Polybilt	0.20	0.05	0.00	0.20	0.20	0.15
32	2154+00	Polybilt	0.30	0.10	0.00	0.30	0.25	0.10
33	2160+00	Polybilt	0.25	0.15	0.00	0.35	0.20	0.15
34	2164+00	Polybilt	0.20	0.15	0.00	0.20	0.20	0.10
35	2170+00	Polybilt	0.20	0.20	0.15	0.50	0.60	0.00
36	2176+00	Exxon	0.15	0.10	0.15	0.55	0.50	0.00
37	2180+00	Exxon	0.20	0.10	0.10	0.50	0.55	0.10
38	2184+00	Exxon	0.25	0.10	0.10	0.30	0.40	0.10
39	2188+00	Exxon	0.20	0.15	0.10	0.60	0.60	0.10
40	2192+00	Exxon	0.20	0.10	0.10	0.30	0.60	0.00
41	2196+00	Exxon	0.15	0.10	0.00	0.45	0.50	0.30
42	2200+00	Exxon	0.25	0.10	0.00	0.55	0.50	0.20
43	2208+00	Kraton	0.30	0.15	0.00	0.40	0.30	0.00
44	2214+00	Kraton	0.20	0.15	0.00	0.40	0.40	0.10
45	2220+00	Kraton	0.15	0.10	0.20	0.55	0.45	0.00
46	2226+00	Kraton	0.20	0.10	0.00	0.40	0.70	0.00
47	2232+00	Kraton	0.20	0.15	0.15	0.50	0.45	0.20
48	2238+00	Kraton	0.20	0.10	0.00	0.15	0.20	0.15
49	2244+00	Kraton	0.20	0.10	0.20	0.40	0.40	0.15
50	2250+00	Kraton	0.20	0.10	0.10	0.40	0.20	0.05
51	2254+00	Kraton	0.20	0.10	0.10	0.40	0.40	0.10
52	2260+00	Kraton	0.25	0.10	0.10	0.30	0.40	0.05

Overall Average Rut Depth	0.22	0.12	0.06	0.39	0.39	0.10
Overall Standard Deviation	0.04	0.03	0.07	0.12	0.16	0.08
Overall Maximum Rut Depth	0.30	0.20	0.20	0.60	0.70	0.30
Overall Minimum Rut Depth	0.15	0.05	0.00	0.15	0.20	0.00

Statistics of Rut Depth by Proposed Section for Modified Binder on East Bound Passing and Driving Lanes

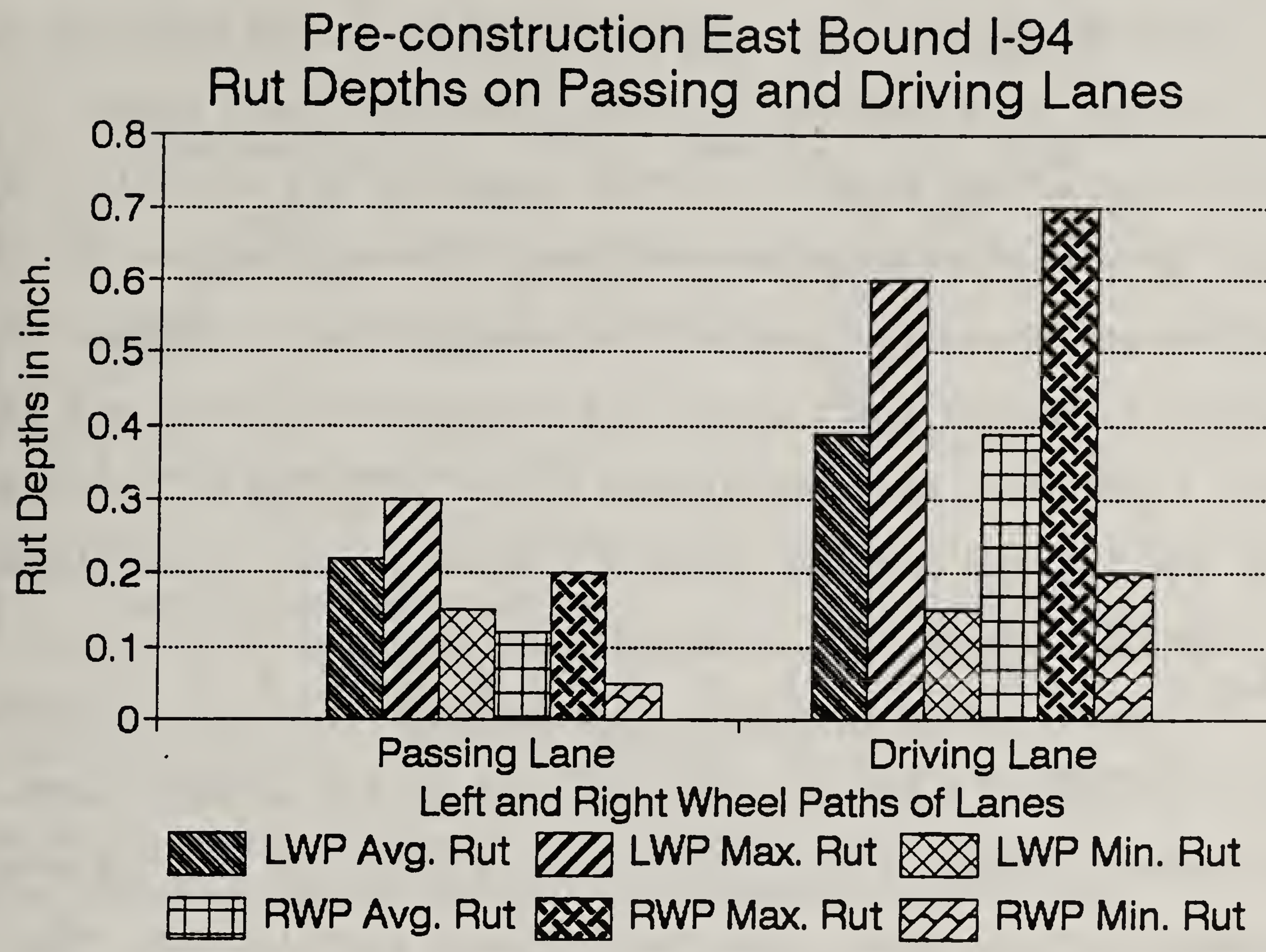
Statistics of Rut Depth on LHWP of EBPL				Statistics of Rut Depth on RHWP of EBPL			
	Average	Maximum	Minimum		Average	Maximum	Minimum
Polybilt	0.24	0.30	0.20	Polybilt	0.12	0.20	0.05
Kraton	0.21	0.30	0.15	Kraton	0.12	0.15	0.10
Exxon	0.20	0.25	0.15	Exxon	0.11	0.15	0.10

Statistics of Rut Depth on LHWP of EBDL				Statistics of Rut Depth on RHWP of EBDL			
	Average	Maximum	Minimum		Average	Maximum	Minimum
Polybilt	0.33	0.50	0.20	Polybilt	0.30	0.60	0.20
Kraton	0.39	0.55	0.15	Kraton	0.39	0.70	0.20
Exxon	0.46	0.60	0.30	Exxon	0.52	0.60	0.40

even though the driving lane had been subjected to overlays and chip seals to improve the rutting on the original pavement surface. The average rut depths on the left and right wheel path of passing lane were 0.22 and 0.12 inches, with the maximum rut depth of 0.30 and 0.20 inches, respectively. The average rut depths on the left and right wheel path of driving lanes were 0.39 inches for both wheel paths with maximum rut depths of 0.6 and 0.7 inches for the respective wheel paths. The standard deviation to the average rutting and minimum rut depths are also presented in Table 10. The average, maximum, and minimum rut depths, by section of the binder used, are also presented in Table 10 for future analysis. Figure 6 shows the relative average and maximum rut depths by section of the east bound lane.

Transverse Pavement Profile

The profilograph records illustrate the actual profile of the pavement surface with reference to the straight profilograph beam. The output of the profilograph was reproduced by taking the coordinates of the profile at an interval of 4 inches. Tables 1A through 9A in Appendix C show the coordinate system for the profile on the west-bound driving lane. Tables 1B through 9B in Appendix C show the coordinate system for the profiles on the west-bound passing lane. Similarly, Tables 10A through 18A and 10B through 18B in Appendix D show the coordinate system of the profiles for driving and passing lanes on the east-bound lane. The results of the differential leveling survey gave the elevation of the profilograph legs positions (at the center line



Note: Left Wheel Path (LWP), Right Wheel Path (RWP)

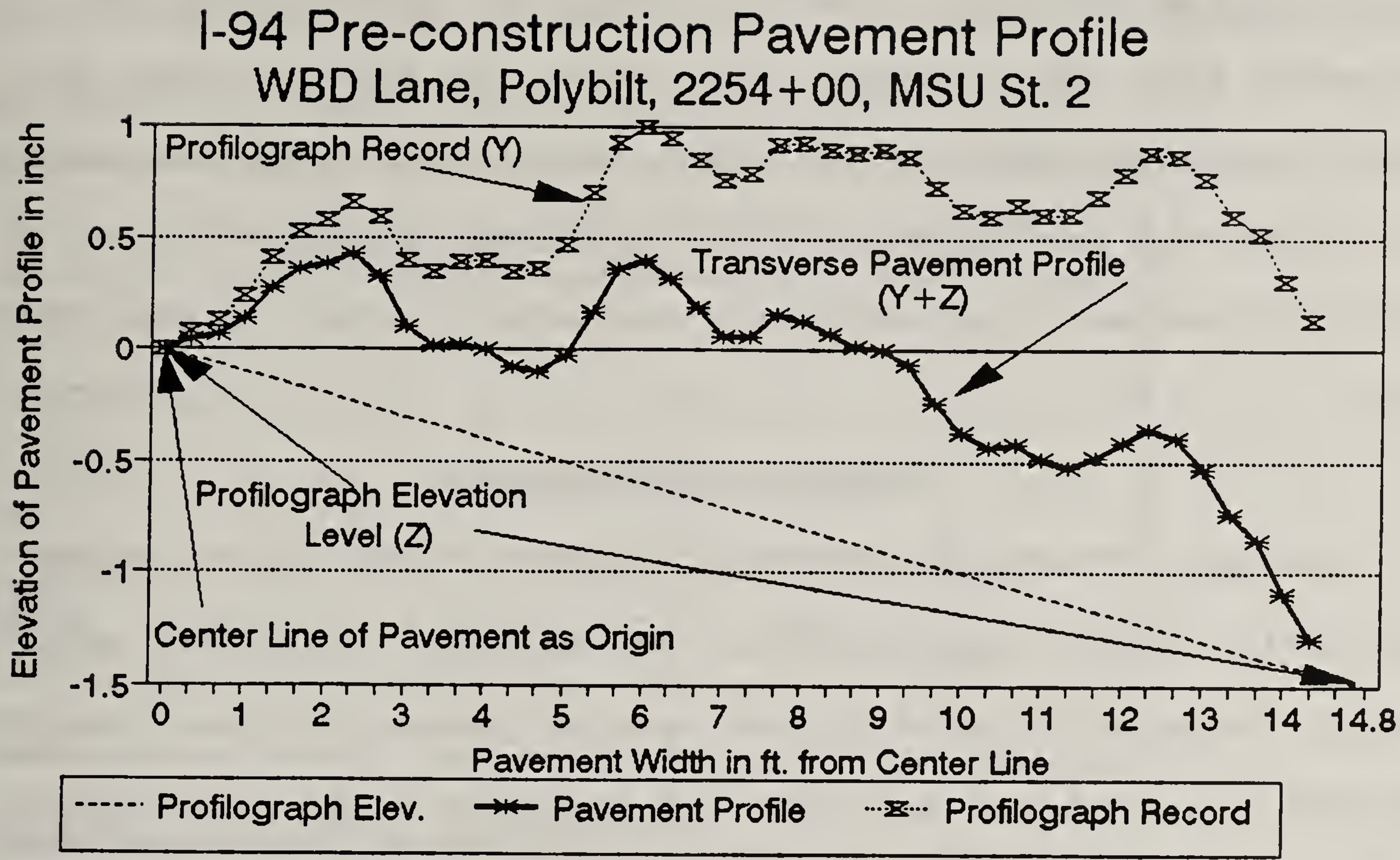
Fig. 6. Average, Maximum, and Minimum Rut Depths on Passing and Driving Lanes

and just beyond the edge of the lane) and the steel pins at the both ends of the pavement. The coordinates of the slope of the profilograph were derived from the elevation. From these coordinates of the profile and the profilograph elevation, the actual pavement profile were obtained. The coordinates of these profiles are shown in Tables 1C through 9C and 1D through 9D in Appendix E for the profiles on the west-bound driving and passing lanes. Similarly, the coordinates of the profiles of the east-bound driving and passing lanes are shown in Tables 10C through 18C and 10D through 18D, respectively, in Appendix F.

A typical pre-construction pavement profile and elevation is shown in Figure 7a for driving lane and 7b for passing lane. The profilograph record (Y) in Figures 7a and 7b are the transverse pavement profiles taken from the Rainhart profilograph. The profilograph elevation (level) (Z) is the differential level of the profilograph indicating the slope of the profilograph on the pavement surface. The actual transverse pavement surface is shown by the transverse pavement profile (Y+Z) in Figures 7a and 7b.

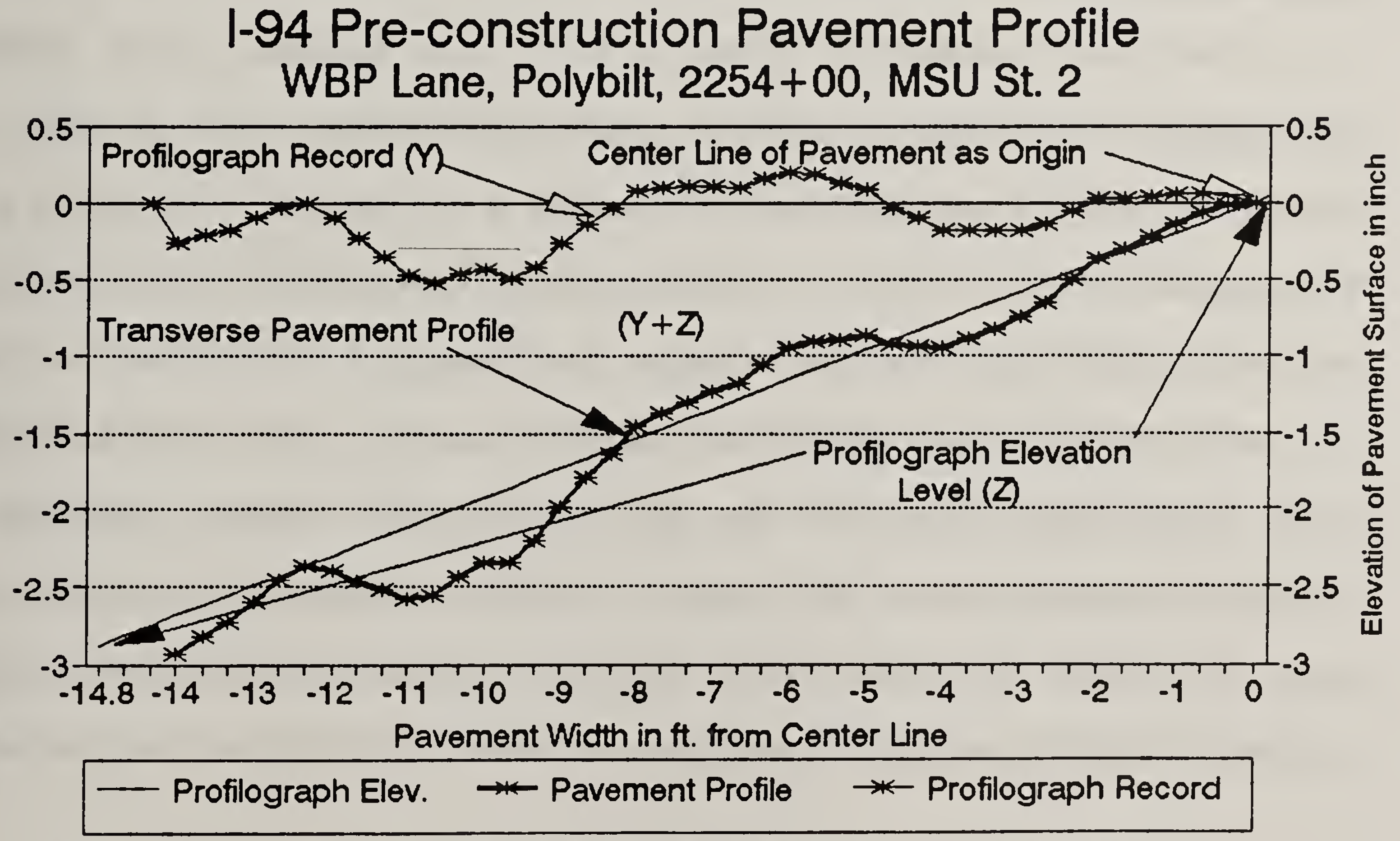
The actual profiles of the pavement at each section on the west-bound lanes are shown in Figures 1A through 13A for the driving lanes and Figures 1B through 13B for the passing lanes in Appendix G. Similarly, the pavement profiles with respect to the slope of the profilograph for the east-bound lanes are shown in Figures 14A through 26A for the driving lanes and Figures 14B through 26B for the passing lanes in Appendix H.

The profiles of the pavement were distorted because of the



Note: Abscissa represents pavement width in ft.; ordinate represents pavement drop in inch.

Fig. 7a. Typical Pre-construction Pavement Profile and Elevation of a Driving Lane



Note: Abscissa represents pavement width in ft.; Ordinate represents pavement drop in inch.

Fig. 7b. Typical Pre-construction Pavement Profile and Elevation of a Passing Lane

excessive rutting. The transverse slope of the pavement was no longer in the original intended shape. The distortions were so excessive that the intended drainage of the pavement was no longer possible. This would affect the stability of the traffic and reduce the performance of the pavement. The distortion of the driving lanes was more extensive compared to that of the passing lanes.

OVERLAY CONSTRUCTION

The specifications and requirements of the construction of the overlay on the experimental test section, using the modified binders, were stipulated in the special provisions section of the contract document and are shown in Appendix A. An overview of the materials used is given in the following sections.

Materials

The following aggregates, asphalt and modifiers were used:

Aggregates

Plant mix surfacing grade B (3/4-inch maximum size aggregate) was used throughout the experimental test section. The source of the aggregate was the Denby pit, which is basically Yellowstone River gravel. The aggregate gradation for the job mix including the high and low range of gradation are shown in Table 11. The required mix gradation was obtained by mixing two stock piles of crushed rock and one pile of natural fines. The bin split percentages used to obtain the job mix specification are shown in Table 12. The field aggregate gradation was monitored constantly by running wet and dry sieve analysis to assure that the mix gradation met the specification. These quality control tests were conducted by the Montana Department of Transportation.

Table 11. Aggregate Gradations for PMBS Grade B

Sieve Size	Job Mix Percent	Specification in Percent Low	High
3/4-inch	100	100	100
1/2-inch	88	81	95
3/8-inch	77	70	84
4M	53	46	60
10M	34	28	40
40M	17	12	22
200M	6.5	5	8

Table 12. Bin Split Percentages

	Coarse Percent	Coarse Fines Percent	Natural Fines Percent
Design	43	37	20
Field	42	37	21

Asphalt

The 85/100 penetration grade asphalt from Exxon Company, USA, Billings, was used in the control section. The base asphalt for the Kraton modified asphalt section was 120/150 penetration grade asphalt from Exxon. This was the grade of asphalt used in the MSU laboratory study. Kraton and Polybilt modifiers were recommended based on the laboratory study on 120/150 grade of base asphalt. However, the Polybilt modified asphalt utilized 85/100 grade asphalt as the base in the experimental test section; this modified asphalt was designated as Polybilt X-1.

Kraton

Kraton thermoplastic rubber polymers are in a unique class of rubber designed for use without vulcanization. Kraton D4141G is a linear SBS (Styrene-Butadiene-Styrene) block copolymer. Kraton D4141G differs fundamentally in molecular structure from the typical plastic or commercial rubber (homopolymer or random copolymers); it is tri-block copolymer with an elastic block in the center and a thermoplastic block on each end. The first "4" identifies the polymer as containing process oil usually napthenic/paraffinic type which is added to the polymer to aid in the mixing of the polymer into bitumen, and to affect desirable changes in the physical properties of the final binder blend. D4141G contains about 29 percent oil. The designation "G" refers to the polymer being in the ground "powder" form again for the purpose of decreasing blending time. The Kraton D4141G, obtained from Shell Development Company, was mixed at a Billings batch-type asphalt mixing plant utilizing 6 percent by weight of Kraton D4141G. The modified asphalt was then trucked by tanker to the job site, a distance of approximately 200 miles.

Polybilt

Polybilt is an EVA, ethylene vinyl acetate, resin and encompasses a large family of petrochemical polymers and polymer concentrates designed for asphalt modification by Exxon Chemical Company. "Polymer 2" was used for Exxon asphalt at a treat rate of 4 percent at MSU laboratory study. However, an EVA polymer modified concentration, mixed in Houston, Texas, was used and mixed with 85/100 grade Exxon at the Exxon Company, USA, Billings. Exxon Chemical chose to use the 85-100 penetration grade asphalt, with "softeners", to attain the desired specifications.

Placement of Overlays

The placement of the overlays started on April 24, 1991. The day was warm and breezy with an ambient temperature of 78°F.

Both the modifiers, Polybilt and Kraton were mixed in Billings. The Polybilt polymer concentrate was brought from the Exxon Company in Houston, Texas. The concentrate was blended with 85-100 penetration grade Exxon asphalt in the proportion of 1:2 at 350°F in a 5000 gallon tank with an agitator at the Exxon Company, Billings. The Kraton D4141G polymer granules were mixed with 120-150 penetration grade of Exxon asphalt at a private asphalt mixing company in Billings. The modifier mixed asphalts were delivered to the site on time without interruption of the paving schedule.

The Polybilt modified asphalt was brought to the site in an 8900 gallon (71367 lbs.) insulated tanker (see photo H). The modified asphalt temperature in the tank was 350°F. The modified asphalt was then transferred to the drained stationary insulated tank of a drum-type continuous bituminous mix plant (see photo I). The asphalt was then pumped into the continuous flow mixing plant (see photo J). The average output of the plant was 407 tons/hr. The plant mix bituminous material was carried in belly dump trucks to the paver. Similar operations were repeated for the Kraton modified asphalt delivered in about a 9000-gallon insulated tanker at 4.15 p.m. and 6.30 p.m.. The modified asphalt temperatures in the tank were 320°F for the first tank and 344°F for the second tank.

Prior to placing the PMBS and leveling courses, the existing 0.20 feet of bituminous surfacing on the driving lane was removed by a cold milling machine (see Photo K). The bituminous surfacing, removed from all cold milled sections, was replaced with PMBS the same day that the milling was done. A tack coat of SS-1 emulsified asphalt was applied prior to the placement of PMBS in the trench. The pavement surface temperature was 79°F. The PMBS was placed with numbers of dump trucks leaving a windrow of PMBS closely followed by a paver (see Photo L). The paver used in the operation was a Blow Knox NE 85 1B PI1804 paver with a capacity of 750 Tons/hr (see Photo M). The lay down temperature ranged from 238-259°F. The paver was closely followed by two 18-ton Dynapak vibrating rollers (see Photo N). Two passes were made to compact seams followed by four more passes. The break down roller-compacted mat was thus produced with the total of 6 passes of vibrating rollers. The rolling operation was completed with the final pass of a 10-ton finishing steel roller (see Photo O). Identical processes were repeated for placement of both modified asphalts and unmodified asphalt in the control section. No difficulties were noticed in the placement of the PMBS with modified asphalt.

The daily average of the data collected on the placement of the PMBS are presented in a tabulated form by date, section, temperature, tonnage placed, and binder type in Table 13. The average, maximum, and minimum statistics of the data for each type of binder were computed and are shown in Table 13. The average, maximum, and minimum temperatures were 320.6, 325, and 300°F for the Polybilt X-1 modified PMBS; and 304.6, 308, and 302°F for Kraton D4141G modified PMBS, and 307.3, 312 and 302°F for unmodified 85-100 Exxon PMBS. The average temperature of the PMBS with Polybilt modified asphalt was the highest. But the average temperature of the Kraton modified asphalt PMBS was lower than that of the unmodified asphalt. Similarly, the average binder temperature of Polybilt modified asphalt was the highest at 346.2°F compared to 339.3°F for Kraton modified asphalt and 300.6°F for unmodified Exxon asphalt. Average asphalt percentage of the PMBS were 5.50 for Polybilt modified asphalt, 5.63 for Kraton modified asphalt, and 5.76 for unmodified asphalt. Figure 8 shows the mix and asphalt binder temperatures of plant mix bituminous surface (PMBS) grade B and binders.

Field Testing

The Marshall stability and flow, unit weight, and voids are shown in Table 14. The overall statistics of mix and aggregate temperatures and Marshall test properties are shown in Table 15. The average, maximum, and minimum values of Marshall stability were 2136, 2226, and 2003 pounds for Polybilt modified asphalt; 2008, 2151, and 1647 pounds for Kraton modified asphalt, and 2068, 2259, and 1851 lbs for unmodified Exxon asphalt. The

Table 13. Data of Placement of Plant Mix Bituminous Surface-Grade B Asphalt Concrete on West and East Bound I-94*

Date	Station		Distance (ft.)	Lane	Asphalt Modifier	Tonnage Placed	Temp. of Mix (F)	Asphalt Percent	Asphalt Weight	Asphalt Temp. (F)	Loads of Mix
	From	To									
4-24-91	2126+92	2174+48	4756	EB Rt. Trench	Polybilt X-1	830.65	325	5.63	46.790	348	35
4-24-91	2174+49	2204+73	3025	EB Rt. Trench	Exxon	517.28	303	5.73	29.640	295-306	22
4-24-91	2204+73	2264+25	5952	EB Rt. Trench	Kraton	1099.74	308	6.04	66.408	348	46
4-25-91	2264+25	2204+50	5975	WB Lt. Trench	Polybilt X-1	1079.56	300	5.34	57.600	352	45
5-1-91	2202+03	2174+73	2730	WB Lt. Trench	Exxon	506.20	302	5.65	28.600	295-306	21
5-1-91	2174+73	2126+92	4781	WB Lt. Trench	Kraton	857.01	305	5.50	47.102	333	38
5-6-91	2126+22	2174+73	4851	EB Rt. 1st. Lift	Polybilt X-1	1025.18	325	5.39	55.210	344	41
5-6-91	2174+73	2204+73	3000	EB Rt. 1st. Lift	Exxon	626.20	308	5.71	38.560	295-306	27
5-6-91	2204+73	2264+25	5952	EB Rt. 1st. Lift	Kraton	1246.61	305	5.51	73.534	330	54
5-7-91	2126+47	2174+73	4826	EB Lt. 1st. Lift	Polybilt X-1	949.66	325	5.51	53.590	344	39
5-7-91	2174+73	2204+73	3000	EB Lt. 1st. Lift	Exxon	600.13	310	5.71	38.570	295-306	27
5-7-91	2204+73	2264+25	5952	EB Lt. 1st. Lift	Kraton	1174.40	305	5.68	75.933	340	54
5-8-91	2264+25	2204+73	5952	WB Lt. 1st. Lift	Polybilt X-1	1219.38	322	5.50	67.080	360	49
5-8-91	2204+73	2174+73	3000	WB Lt. 1st. Lift	Exxon	623.37	312	6.00	40.190	295-306	27
5-8-91	2174+73	2126+92	4781	WB Lt. 1st. Lift	Kraton	996.87	305	5.60	57.851	340	42
5-8-91	2264+25	2204+73	5952	WB Rt. 1st. Lift	Polybilt X-1	1179.60	322	5.50	66.600	356	48
5-9-91	2204+73	2174+73	3000	WB Rt. 1st. Lift	Exxon	597.69	307	5.76	34.410	295-306	24
5-9-91	2174+73	2126+92	4781	WB Rt. 1st. Lift	Kraton	945.55	305	5.60	58.046	332	52
5-9-91	2126+92	2174+73	4781	EB Rt. 2nd. Lift	Polybilt X-1	1227.49	320	5.53	68.410	351	50
5-10-91	2174+73	2204+73	3000	EB Rt. 2nd. Lift	Exxon	809.47	304	5.76	48.050	295-306	34
5-10-91	2204+73	2263+91	5918	EB Rt. 2nd. Lift	Kraton	1597.85	304	5.57	89.074	345	64
5-14-91	2126+62	2174+73	4811	EB Lt. 2nd. Lift	Polybilt X-1	1049.59	323	5.52	57.900	338	42
5-14-91	2174+73	2204+73	3000	EB Lt. 2nd. Lift	Exxon	646.08	308	5.76	37.240	295-306	26
5-14-91	2204+73	2264+25	5952	EB Lt. 2nd. Lift	Kraton	1273.22	303	5.55	70.718	334	51
5-16-91	2264+25	2204+73	5952	WB Lt. 2nd. Lift	Polybilt X-1	1616.98	323	5.50	89.000	338	65
5-16-91	2204+73	2174+73	3000	WB Lt. 2nd. Lift	Exxon	842.00	312	5.85	49.680	295-306	36
5-16-91	2174+73	2126+92	4781	WB Lt. 2nd. Lift	Kraton	1282.14	302	5.60	72.150	343	52
5-17-91	2264+25	2204+73	5952	WB Rt. 2nd. Lift	Polybilt X-1	1262.51	321	5.55	70.040	331	51
5-17-91	2204+73	2174+73	3000	WB Rt. 2nd. Lift	Exxon	623.70	307	5.71	35.630	295-306	25
5-17-91	2174+73	2126+92	4781	WB Rt. 2nd. Lift	Kraton	1022.85	304	5.66	57.857	348	42

* Source: Montana Department of Transportation, Glendive

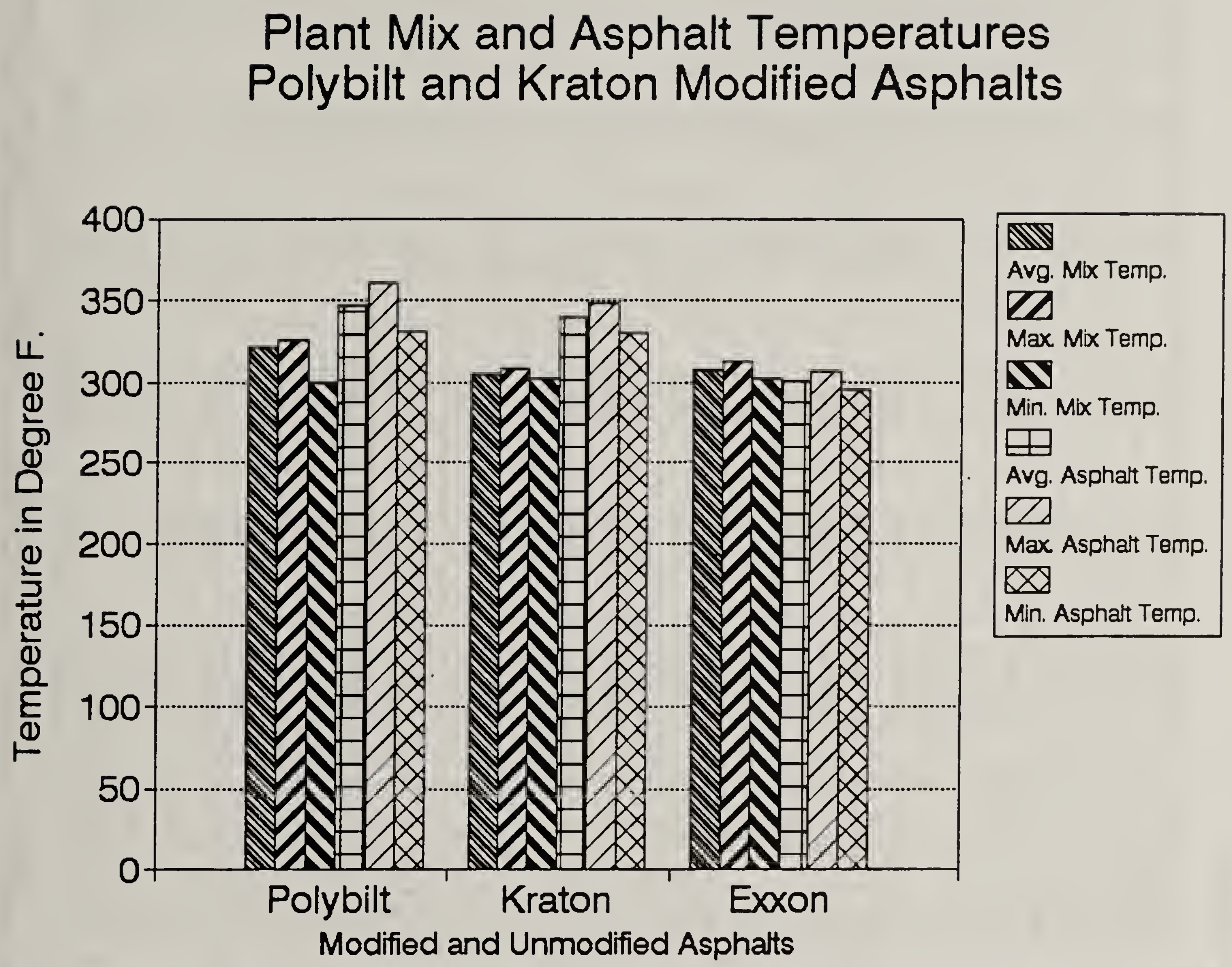


Figure 8. Plant Mix and Asphalt Temperatures of Plant Mix Bituminous Surface

Table 14. Daily Average of Marshall Stability and Flow, Unit Weight, and Percent Air Voids of Specimens Made from PMBS Grade B*

Date	Station		Distance (ft.)	Lane	Asphalt Modifier	Asphalt Percent	Marshall		Percent Air Voids	Density
	From	To					Stability	Flow		
4-24-91	2126+92	2174+48	4756	EB Rt. Trench	Polybilt X-1	5.63	2027	10.00	2.00	2.361
4-24-91	2174+49	2204+73	3025	EB Rt. Trench	Exxon	5.73	2124	10.00	2.90	2.356
4-24-91	2204+73	2264+25	5952	EB Rt. Trench	Kraton	6.04	1987	12.00	1.70	2.349
4-25-91	2264+25	2204+50	5975	WB Lt. Trench	Polybilt X-1	5.34	2027	10.00	2.00	2.361
5-1-91	2202+03	2174+73	2730	WB Lt. Trench	Exxon	5.65	2112	10.00	3.20	2.353
5-1-91	2174+73	2126+92	4781	WB Lt. Trench	Kraton	5.50	2011	12.00	3.80	2.340
5-6-91	2126+22	2174+73	4851	EB Rt. 1st. Lift	Polybilt X-1	5.39	2133	11.00	4.30	2.332
5-6-91	2174+73	2204+73	3000	EB Rt. 1st. Lift	Exxon	5.71	1964	11.00	3.00	2.349
5-6-91	2204+73	2264+25	5952	EB Rt. 1st. Lift	Kraton	5.51	1938	11.00	4.30	2.327
5-7-91	2126+47	2174+73	4826	EB Lt. 1st. Lift	Polybilt X-1	5.51	2191	9.00	2.70	2.362
5-7-91	2174+73	2204+73	3000	EB Lt. 1st. Lift	Exxon	5.71	1851	10.00	3.30	2.349
5-7-91	2204+73	2264+25	5952	EB Lt. 1st. Lift	Kraton	5.68	2154	10.00	2.70	2.350
5-8-91	2264+25	2204+73	5952	WB Lt. 1st. Lift	Polybilt X-1	5.50	2226	10.00	2.50	2.361
5-8-91	2204+73	2174+73	3000	WB Lt. 1st. Lift	Exxon	6.00	2069	10.00	3.20	2.354
5-8-91	2174+73	2126+92	4781	WB Lt. 1st. Lift	Kraton	5.60	2062	11.00	3.50	2.342
5-8-91	2264+25	2204+73	5952	WB Rt. 1st. Lift	Polybilt X-1	5.50	2226	10.00	2.50	2.361
5-9-91	2204+73	2174+73	3000	WB Rt. 1st. Lift	Exxon	5.76	2259	11.00	2.40	2.361
5-9-91	2174+73	2126+92	4781	WB Rt. 1st. Lift	Kraton	5.60	2161	12.00	3.10	2.344
5-9-91	2126+92	2174+73	4781	EB Rt. 2nd. Lift	Polybilt X-1	5.53	2125	11.00	2.70	2.359
5-10-91	2174+73	2204+73	3000	EB Rt. 2nd. Lift	Exxon	5.76	2091	11.00	2.70	2.355
5-10-91	2204+73	2263+91	5918	EB Rt. 2nd. Lift	Kraton	5.57	2022	10.00	3.80	2.337
5-14-91	2126+62	2174+73	4811	EB Lt. 2nd. Lift	Polybilt X-1	5.52	2003	10.00	3.20	2.348
5-14-91	2174+73	2204+73	3000	EB Lt. 2nd. Lift	Exxon	5.76	2112	9.00	2.80	2.356
5-14-91	2204+73	2264+25	5952	EB Lt. 2nd. Lift	Kraton	5.55	1981	11.00	3.40	2.337
5-16-91	2264+25	2204+73	5952	WB Lt. 2nd. Lift	Polybilt X-1	5.50	2217	10.00	3.00	2.356
5-16-91	2204+73	2174+73	3000	WB Lt. 2nd. Lift	Exxon	5.85	2063	10.00	2.70	2.355
5-16-91	2174+73	2126+92	4781	WB Lt. 2nd. Lift	Kraton	5.60	1647	10.00	3.30	2.327
5-17-91	2264+25	2204+73	5952	WB Rt. 2nd. Lift	Polybilt X-1	5.55	2185	10.00	2.80	2.351
5-17-91	2204+73	2174+73	3000	WB Rt. 2nd. Lift	Exxon	5.71	2041	9.00	2.80	2.352
5-17-91	2174+73	2126+92	4781	WB Rt. 2nd. Lift	Kraton	5.66	2118	11.00	3.80	2.336

* Source: Montana Department of Transportation, Glendive

Table 15. Average Values of Mix and Asphalt Temperatures, Asphalt Percent, Stability, Flow, Unit Weight and Air Voids and Design Specification.

Binder	Mix Temperature (F)			Total Mix
	Average	Maximum	Minimum	Tonnage
Polybilt	320.60	325.00	300.00	11440.60
Kraton	304.60	308.00	302.00	11496.24
Exxon	307.30	312.00	302.00	6392.12

Binder	Asphalt Temperature (F)			Total Asp.
	Average	Maximum	Minimum	Tonnage
Polybilt	346.20	360.00	331.00	632.22
Kraton	339.30	348.00	330.00	668.67
Exxon	300.50	306.00	295.00	380.57

Binder	Asphalt Percent			Design
	Average	Maximum	Minimum	Specification
Polybilt	5.50	5.63	5.34	5.60
Kraton	5.63	6.04	5.50	6.00
Exxon	5.76	6.00	5.65	5.90

Binder	Marshall Stability in lbs.			Design
	Average	Maximum	Minimum	Specification
Polybilt	2136.00	2226.00	2003.00	1620.00
Kraton	2008.10	2161.00	1647.00	1725.00
Exxon	2068.60	2259.00	1851.00	1615.00

Binder	Marshall Flow in 1/100 inch			Design
	Average	Maximum	Minimum	Specification
Polybilt	10.10	11.00	9.00	8.00
Kraton	11.00	12.00	10.00	11.00
Exxon	10.10	11.00	9.00	9.00

Binder	Percent Air Voids			Design
	Average	Maximum	Minimum	Specification
Polybilt	2.77	4.30	2.00	3.50
Kraton	3.34	4.30	1.70	3.50
Exxon	2.90	3.30	2.40	3.30

Binder	Unit Weight in gm/cc			Design
	Average	Maximum	Minimum	Specification
Polybilt	2.355	2.362	2.332	2.319
Kraton	2.339	2.350	2.327	2.315
Exxon	2.354	2.361	2.349	2.325

stability of the Polybilt modified asphalt was higher than both the Kraton modified and unmodified asphalt. The minimum stability of the Kraton modified asphalt was lower than the specification. The variations between the maximum and minimum stability of the Kraton modified and unmodified asphalt were high. Figure 9 shows the Marshall stability of PMBS grade B specimens with modified and unmodified asphalts. The average percent air voids at 3.34 percent of Kraton modified asphalt was the highest compared to 2.77 percent for Polybilt modified asphalt and 2.9 percent for unmodified Exxon asphalt. Figure 10 shows the percent air voids of PMBS grade B specimens with modified and unmodified asphalt binders. The average Marshall flow values varied between 10 and 11 1/100 inches. The average unit weight varied between 2.339 and 2.355 g/cc, and were higher than design specification.

The field densities of the compacted mat pavement at each section of modified asphalt and the control section were measured using nuclear densimeter. The temperature of the pavement was also measured. Four readings of the nuclear densimeter were taken for each setting. The average of the four readings are presented in a tabulated format in the quality assurance evaluation of plant mix density in Table 16. The densities measured by the nuclear densimeter were compared with the densities of the laboratory test specimens, prepared with the respective plant mix of aggregate and binder using 50 blows compaction of a Marshall hammer. None of the test results of the pavement was less than 95 percent of target density. In fact, some of them were between 97

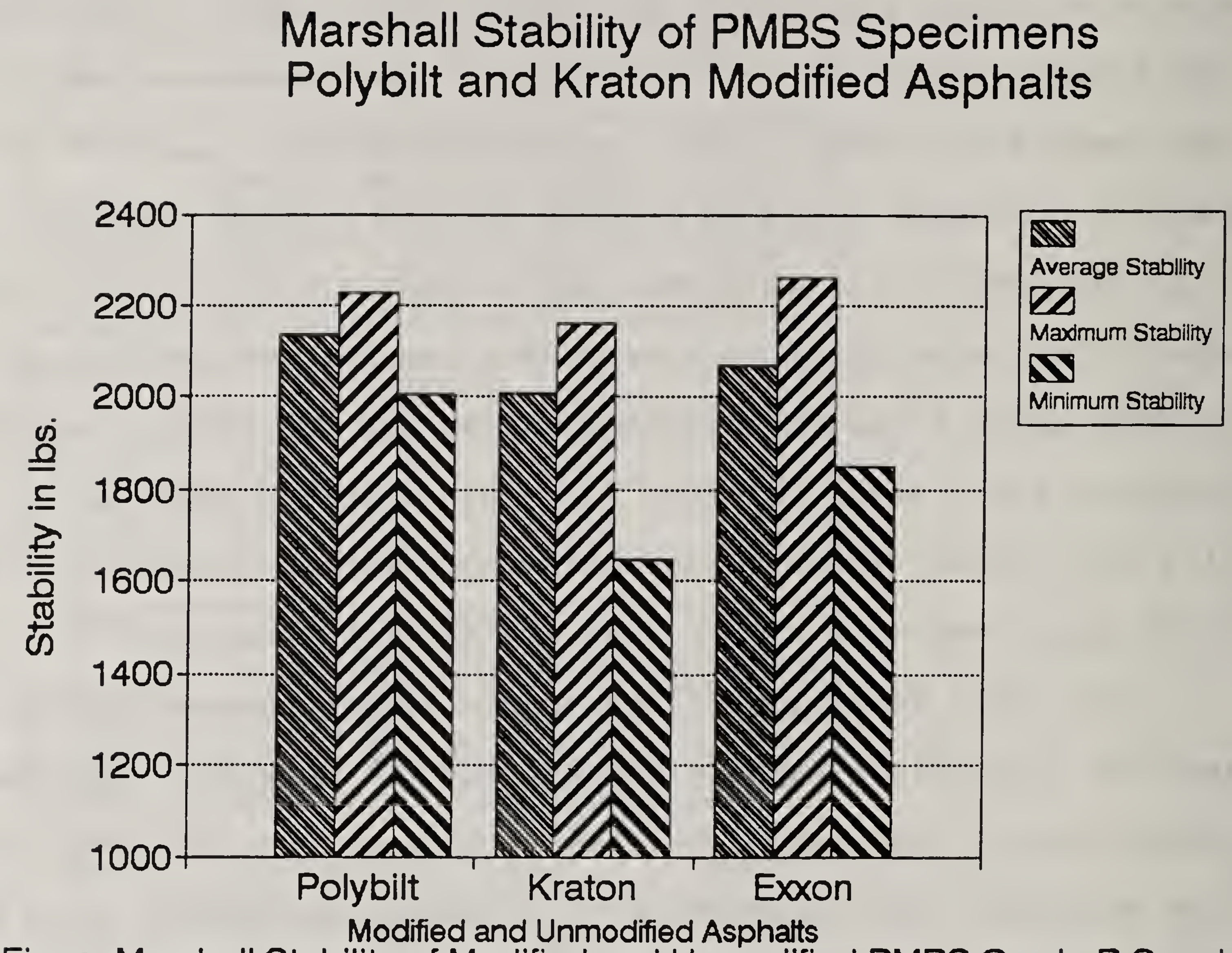


Fig. 9. Marshall Stability of Modified and Unmodified PMBS Grade B Specimens

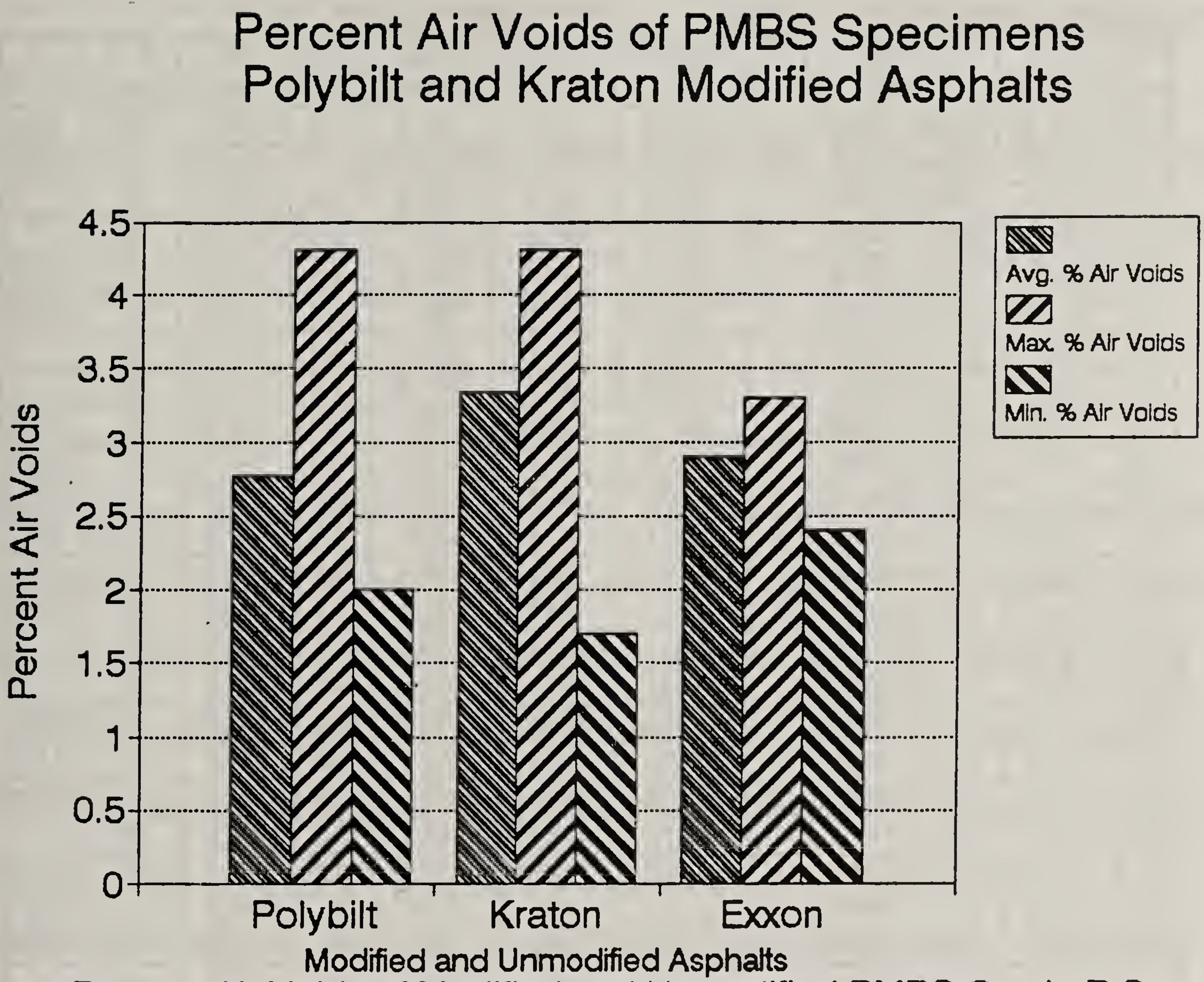


Fig.10. Percent Air Voids of Modified and Unmodified PMBS Grade B Specimens

Table 16. Quality Assurance Evaluation of Plant Mix Density*

Project: IR 94-5(25)185 Type Material: PMS Grade B

Designation: Prairie County Line - West Nuclear Device Number: 7561

Test No.	Date Tested	Station Tested	Lift	Distance Lt or Rt	Marshall Density	Guage Reading	Core Corr	Test Density	% of Target	A
25	4-24-91	2157+82WB	0	9.0 Rt	144.7	138.4	0.0	138.4	96	0.33
35	4-25-91	2233+74WB	0	9.0 Rt	147.0	140.5	4.3	144.8	99	0.33
36	4-25-91	2230+47WB	0	3.5 Rt	147.0	138.6	4.3	142.9	97	
37	4-25-91	2206+94WB	0	6.0 Lt	147.0	137.1	4.3	141.4	96	
39	5-1-91	2196+83WB	0	9.0 Lt	147.5	139.0	2.9	141.9	96	0.38
40	5-1-91	2185+47WB	0	8.0 Lt	147.5	139.9	2.9	142.8	97	0.33
46	5-6-91	2150+75EBp	1	5.0 RT	144.7	139.7	0.0	139.7	97	
47	5-6-91	2190+50EB	1	6.0 Rt	147.5	140.8	3.8	144.6	98	
48	5-6-91	2207+10EBk	1	2.0 Rt	144.5	139.8	0.0	139.8	97	0.45
49	5-6-91	2228+85EBk	1	10.0 Rt	144.5	140.6	0.0	140.6	97	0.38
50	5-6-91	2263+00EBk	1	14.0 Rt	144.5	138.2	0.0	138.2	96	0.33
53	5-7-91	2152+42EBp	1	3.0 Lt	147.4	137.0	4.8	141.8	96	0.45
54	5-7-91	2195+80EB	1	14.0 Lt	147.5	138.8	3.8	142.6	97	0.38
55	5-7-91	2215+20EBk	1	9.0 Lt	146.6	135.3	4.5	139.8	95	0.33
61	5-8-91	2213+25WB	1	5.0 Lt	147.4	139.8	4.8	144.6	98	
62	5-8-91	2170+00WB	1	7.0 Lt	146.6	139.8	4.5	144.3	98	
63	5-8-91	2149+50WB	1	6.0 Lt	146.6	138.5	4.5	143.0	98	0.45
64	5-8-91	2128+10WB	1	13.0 Lt	146.6	140.2	4.5	144.7	99	0.38
65	5-8-91	2242+00WB	1	13.0 Rt	147.4	137.1	4.8	141.9	96	0.33
66	5-9-91	2201+50WB	1	3.0 Rt	147.5	137.1	3.8	140.9	96	
67	5-9-91	2184+20WB	1	3.0 Rt	147.5	139.9	3.8	143.7	97	
68	5-9-91	2143+70WB	1	4.0 Rt	146.6	137.8	4.5	142.3	97	0.45
69	5-9-91	2138+00WB	1	10.0 Rt	146.6	136.3	4.5	140.8	96	0.38
76	5-10-91	2246+50EBk	2	3.0 Rt	143.2	140.9	0.0	140.9	98	
77	5-10-91	2256+25EBk	2	5.0 Rt	143.2	139.8	0.0	139.8	98	
83	5-14-91	2146+20EBp	2	8.0 Lt	147.2	138.3	3.9	142.2	97	0.45
84	5-14-91	2161+80EBp	2	5.0 Lt	147.2	136.9	3.9	140.8	96	0.38
85	5-14-91	2208+25EBk	2	7.0 Lt	146.5	137.4	5.3	142.7	97	0.33
91	5-16-91	2212+40WBp	2	4.0 Lt	147.2	137.2	3.9	141.1	96	
92	5-16-91	2180+00WB	2	11.0 Lt	146.8	138.0	3.6	141.6	96	
93	5-16-91	2168+10WBk	2	3.0 Lt	146.6	136.5	5.3	141.8	97	0.45
94	5-16-91	2141+60WBk	2	6.0 Lt	146.6	138.1	5.3	143.4	98	0.38
96	5-17-91	2248+00WBp	2	7.0 Rt	147.2	135.8	3.9	139.7	95	
97	5-17-91	2221+50WBp	2	10.0 Rt	147.2	136.7	3.9	140.7	96	
98	5-17-91	2190+20WB	2	5.0 Rt	146.8	139.9	3.6	143.5	98	0.45
99	5-17-91	2175+75WB	2	5.0 Rt	146.8	135.9	3.6	139.5	95	0.38
100	5-17-91	2138+70WBk	2	12.0 Rt	146.6	136.9	5.3	142.2	97	0.33

* Source: Montana Depertment of Transportation, Glendive

and 98 percent.

Core Density and Percent Air Voids

The cores of the pavement were taken from east and west bound lanes. The data on the cores of the pavement on both modified and asphalt sections were provided by Montana Department of Transportation (MODT), Glendive. A summary of the data is presented in Table 17. The MODT has included this project in the yearly MT-137 evaluations. The lifts (including the trench) were separated from each other and bulk specific gravity and Rice specific gravity were ran on all of them. This was done to increase the accuracy of the in-place percent air voids determinations. The average percent air voids was ranged between 3.2 for Polybilt Modified asphalt section to 4.5 for unmodified asphalt at control section. However, the ranges of percent air voids of cores from all three sections were large. The maximum percent air voids were 6.8 percent for Kraton modified pavement, 5.4 percent for unmodified asphalt control section, and 5.2 percent for Polybilt modified section. Similarly, the minimum percent air voids for Kraton modified section was lowest at 1.8 percent compared to that of Polybilt modified section (1.9 percent) and unmodified control section (3.5 percent).

This operation showed that the polymer modified asphalt could be obtained locally, mixed with specified aggregate gradation, and placed without difficulties. The whole operation went on smoothly in spite of the labor strike by the Montana Department of Highway technicians on the afternoon of April 25,

Table 17. Density and Percent Air Voids of Pavement Cores*

Date	Station	Ref. C/L (ft.)	Modifier Used	Lift	Lane	Wheel-Path	Bulk Sp. Gravity	Density lb/cu. ft.	Percent Air Voids
5-24-91	2140+00	1.7 Left	Kraton	2	W.B. Driving	Inside	2.278	142.1	6.8
	2140+00	1.7 Left	Kraton	1	W.B. Driving	Inside	2.378	148.4	1.8
	2140+00	1.7 Left	Kraton	Trench	W.B. Driving	Inside	2.311	144.2	4.5
						Average	2.322	144.9	4.4
5-24-91	2193+97	4.1 Right	None	2	W.B. Passing	Inside	2.315	144.5	5.4
	2193+97	4.1 Right	None	1	W.B. Passing	Inside	2.354	146.9	3.5
						Average	2.335	145.7	4.5
5-23-91	2224+00	5.9 Left	Polybilt	2	W.B. Driving	Inside	2.319	144.7	4.1
	2224+00	5.9 Left	Polybilt	1	W.B. Driving	Inside	2.349	146.6	3.3
	2224+00	5.9 Left	Polybilt	Trench	W.B. Driving	Inside	2.330	145.4	2.8
						Average	2.333	145.6	3.4
5-24-91	2139+00	1.7 Right	Polybilt	2	E.B. Driving	Inside	2.378	148.4	1.9
	2139+00	1.7 Right	Polybilt	1	E.B. Driving	Inside	2.365	147.6	2.3
	2139+00	1.7 Right	Polybilt	Trench	E.B. Driving	Inside	2.347	146.5	2.7
						Average	2.363	147.5	2.3
5-24-91	2160+00	11.4 Right	Polybilt	2	E.B. Driving	Outside	2.295	143.2	5.0
	2160+00	11.4 Right	Polybilt	1	E.B. Driving	Outside	2.311	144.2	5.2
	2160+00	11.4 Right	Polybilt	Trench	E.B. Driving	Outside	2.416	150.8	1.9
						Average	2.341	146.1	4.0
5-24-91	2227+00	6.8 Right	Kraton	2	E.B. Driving	Outside	2.339	146.0	3.6
	2227+00	6.8 Right	Kraton	1	E.B. Driving	Outside	2.334	145.7	4.0
	2227+00	6.8 Right	Kraton	Trench	E.B. Driving	Outside	2.341	151.7	3.3
						Average	2.338	147.8	3.6

Statistics of Core Specific Gravity and Percent Air Voids

Modifier Used	Statistics	Bulk Sp. Gravity	Density lb/cu. ft.	Percent Air Voids
Polybilt	Average	2.346	146.4	3.2
	Maximum	2.416	150.8	5.2
	Minimum	2.295	143.2	1.9
	Std. Div.	0.037	2.3	1.3
Kraton	Average	2.330	146.4	4.0
	Maximum	2.378	151.7	6.8
	Minimum	2.278	142.1	1.8
	Std. Div.	0.033	3.3	1.6
None	Average	2.335	145.7	4.5
	Maximum	2.354	146.9	5.4
	Minimum	2.315	144.5	3.5
	Std. Div.	0.028	1.7	1.3

* Source: Montana Department of Transportation, Glendive

1991.

Cost Information

The costs of the modified asphalt and the plant mix were bid as follows:

Description	**Cost (Bid)**
AC 85-100 Exxon (unmodified)	- $126.20/Ton
Kraton D4141G modified 120/150 Exxon	- $376.00/Ton
Polybilt X-1 modified 85-100 Exxon	- $239.20/Ton
Plant mix	- $950/Ton

POST CONSTRUCTION RUT MEASUREMENTS

The post construction pavement surface survey was conducted on May 31 and June 1, 1991. There were no cracks on the freshly laid pavement overlays. The pavement surface was smooth and black with closely held aggregates (see Photo) in all three sections (two modified and a control sections). There were no visible bleeding, rutting, or any other distress.

The transverse profiles of the post construction pavement were taken about 15 days after completion of the overlay construction. The transverse profile records of the post-construction pavement surface were obtained by running the Rainhart transverse profilograph at the same stations as before. The exact stations were located with the help of the reference bar along the right-of-way fence and a metal detector to locate the steel pins at the same station. The center points of the pavement were marked from the distances measured earlier in the pre-construction pavement survey shown in Tables 2 and 3. The profilograph was set, as before, on the driving and passing lanes of each of the east and west-bound lanes. The traffic was diverted to the other lane when recording of the profiles were in progress. The outputs of profilograph records were obtained for each setting at every station.

The rut depths, as defined in the distress identification manual, were measured on the left and right wheel path of each of driving and passing lanes. The rut depths were measured from the records of the profilograph. The results are tabulated in Table 18 for the west-bound lane and Table 19 for the east-bound lane. The average, maximum, and minimum rut depths for each of wheel path are also shown in Table 18. The average rut depth on the left and right wheel paths of the west-bound passing lane were .04 and .06 inches respectively, with maximum depth of 0.1 and 0.15 inches. Similarly, the average rut depth on left and right wheel paths of the driving west-bound lanes were 0.04 and 0.03 inches respectively, with maximum rut depth of 0.1 inch on each. Table 18 also shows the average, maximum, and minimum rut depths on left and right wheel paths on both the driving and passing lanes by sections (two modified asphalts and control section).

Similarly, the rut depths on the post-construction pavement surface on the east-bound lane were obtained and are shown in Table 19. The average ruts on the left and right passing lane were 0.03 and 0.08 inches respectively, with maximum rut depths of 0.05 and 0.1 inches. On the driving lane, the left and right

Table 18. Post-construction Rut Depth from Profilograph Results on West Bound Interstate Highway I-94

MSU Station Number	Highway Station	Binder Used	West Bound Passing Lane (WBPL)			West Bound Driving Lane (WBDL)		
			Left Hand Wheel Path (LHWP) (in)	Right Hand Wheel Path (RHWP) (in)	Center (in)	Left Hand Wheel Path (LHWP) (in)	Right Hand Wheel Path (RHWP) (in)	Center (in)
1	2260+00	Polybilt	0.00	0.05	0.00	0.05	0.05	0.00
2	2254+00	Polybilt	0.05	0.05	0.00	0.05	0.00	0.00
3	2250+00	Polybilt	0.10	0.05	0.00	0.05	0.00	0.00
4	2244+00	Polybilt	0.10	0.05	0.00	0.05	0.05	0.00
5	2238+00	Polybilt	0.00	0.00	0.00	0.00	0.00	0.00
6	2232+00	Polybilt	0.05	0.05	0.00	0.00	0.05	0.00
7	2226+00	Polybilt	0.00	0.00	0.00	0.05	0.05	0.00
8	2220+00	Polybilt	0.00	0.05	0.00	0.05	0.05	0.00
9	2214+00	Polybilt	0.05	0.00	0.00	0.05	0.05	0.00
10	2208+00	Polybilt	0.05	0.05	0.00	0.05	0.00	0.00
11	2200+00	Exxon	0.05	0.05	0.00	0.10	0.05	0.00
12	2196+00	Exxon	0.05	0.00	0.00	0.10	0.10	0.00
13	2192+00	Exxon	0.05	0.15	0.00	0.10	0.10	0.00
14	2188+00	Exxon	0.05	0.15	0.00	0.05	0.05	0.00
15	2184+00	Exxon	0.10	0.10	0.00	0.10	0.05	0.00
16	2180+00	Exxon	0.10	0.10	0.00	0.05	0.05	0.00
17	2176+00	Exxon	0.05	0.10	0.00	0.05	0.05	0.00
18	2170+00	Kraton	0.05	0.10	0.00	0.05	0.05	0.00
19	2164+00	Kraton	0.05	0.10	0.00	0.05	0.00	0.00
20	2160+00	Kraton	0.05	0.05	0.00	0.00	0.00	0.00
21	2154+00	Kraton	0.05	0.05	0.00	0.00	0.00	0.00
22	2150+00	Kraton	0.05	0.00	0.00	0.00	0.00	0.00
23	2144+00	Kraton	0.05	0.05	0.00	0.00	0.00	0.00
24	2138+00	Kraton	0.00	0.15	0.00	0.05	0.05	0.00
25	2134+00	Kraton	0.00	0.05	0.00	0.00	0.00	0.00
26	2130+00	Kraton	0.00	0.05	0.00	0.00	0.00	0.00

Average Rut Depth	0.04	0.06	0.00	0.04	0.03	0.00
Standard Deviation	0.03	0.05	0.00	0.03	0.03	0.00
Maximum Rut Depth	0.10	0.15	0.00	0.10	0.10	0.00
Minimum Rut Depth	0.00	0.00	0.00	0.00	0.00	0.00

Statistics of Rut Depth by Section of Modified Binder Used on West Bound Passing and Driving Lanes

Statistics of Rut Depth on LHWP of WBPL				Statistics of Rut Depth on RHWP of WBPL			
	Average	Maximum	Minimum		Average	Maximum	Minimum
Polybilt	0.04	0.10	0.00	Polybilt	0.04	0.05	0.00
Kraton	0.03	0.05	0.00	Kraton	0.07	0.15	0.00
Exxon	0.06	0.10	0.05	Exxon	0.09	0.15	0.00

Statistics of Rut Depth on LHWP of WBDL				Statistics of Rut Depth on RHWP of WBDL			
	Average	Maximum	Minimum		Average	Maximum	Minimum
Polybilt	0.04	0.05	0.00	Polybilt	0.03	0.05	0.00
Kraton	0.02	0.05	0.00	Kraton	0.01	0.05	0.00
Exxon	0.08	0.10	0.05	Exxon	0.06	0.10	0.05

Table 19. Post-construction Rut Depth from Profilograph Results on East Bound Interstate Highway I-94

			East Bound Passing Lane (EBPL)			East Bound Driving Lane (EBDL)		
MSU Station Number	Highway Station	Binder Used	Left Hand Wheel Path (LHWP) (in)	Right Hand Wheel Path (RHWP) (in)	Center (in)	Left Hand Wheel Path (LHWP) (in)	Right Hand Wheel Path (RHWP) (in)	Center (in)
27	2130+00	Polybilt	0.05	0.10	0.00	0.00	0.10	0.00
28	2134+00	Polybilt	0.05	0.10	0.00	0.00	0.00	0.00
29	2138+00	Polybilt	0.00	0.05	0.00	0.00	0.00	0.00
30	2144+00	Polybilt	0.00	0.10	0.00	0.00	0.00	0.00
31	2150+00	Polybilt	0.05	0.05	0.00	0.00	0.00	0.00
32	2154+00	Polybilt	0.00	0.05	0.00	0.00	0.00	0.05
33	2160+00	Polybilt	0.05	0.05	0.00	0.00	0.00	0.00
34	2164+00	Polybilt	0.05	0.10	0.00	0.00	0.00	0.00
35	2170+00	Polybilt	0.05	0.10	0.00	0.00	0.05	0.00
36	2176+00	Exxon	0.00	0.05	0.00	0.05	0.05	0.00
37	2180+00	Exxon	0.05	0.10	0.00	0.00	0.00	0.00
38	2184+00	Exxon	0.05	0.10	0.00	0.00	0.00	0.00
39	2188+00	Exxon	0.05	0.10	0.00	0.05	0.05	0.00
40	2192+00	Exxon	0.05	0.05	0.00	0.05	0.00	0.00
41	2196+00	Exxon	0.00	0.10	0.00	0.10	0.05	0.00
42	2200+00	Exxon	0.05	0.10	0.00	0.05	0.05	0.00
43	2208+00	Kraton	0.05	0.05	0.00	0.00	0.00	0.00
44	2214+00	Kraton	0.05	0.10	0.00	0.00	0.00	0.00
45	2220+00	Kraton	0.00	0.00	0.00	0.00	0.00	0.00
46	2226+00	Kraton	0.05	0.10	0.00	0.00	0.00	0.00
47	2232+00	Kraton	0.00	0.10	0.00	0.00	0.00	0.00
48	2238+00	Kraton	0.00	0.05	0.00	0.00	0.00	0.00
49	2244+00	Kraton	0.05	0.05	0.00	0.00	0.00	0.00
50	2250+00	Kraton	0.05	0.05	0.00	0.00	0.05	0.00
51	2254+00	Kraton	0.05	0.10	0.00	0.05	0.05	0.00
52	2260+00	Kraton	0.05	0.10	0.00	0.00	0.00	0.00

Overall Average Rut Depth	0.03	0.08	0.00	0.01	0.02	0.00
Overall Standard Deviation	0.02	0.03	0.00	0.03	0.03	0.01
Overall Maximum Rut Depth	0.05	0.10	0.00	0.10	0.10	0.05
Overall Minimum Rut Depth	0.00	0.00	0.00	0.00	0.00	0.00

Statistics of Rut Depth by Section of Modified Binder Used on East Bound Passing and Driving Lanes

Statistics of Rut Depth on LHWP of EBPL				Statistics of Rut Depth on RHWP of EBPL			
	Average	Maximum	Minimum		Average	Maximum	Minimum
Polybilt	0.03	0.05	0.00	Polybilt	0.08	0.10	0.05
Kraton	0.04	0.05	0.00	Kraton	0.07	0.10	0.00
Exxon	0.04	0.05	0.00	Exxon	0.09	0.10	0.05

Statistics of Rut Depth on LHWP of EBDL				Statistics of Rut Depth on RHWP of EBDL			
	Average	Maximum	Minimum		Average	Maximum	Minimum
Polybilt	0.00	0.00	0.00	Polybilt	0.02	0.10	0.00
Kraton	0.01	0.05	0.00	Kraton	0.01	0.05	0.00
Exxon	0.04	0.10	0.00	Exxon	0.03	0.05	0.00

average rut depths were 0.01 and 0.02 inches respectively, with maximum rut depth of 0.1 inch on each path. The average, maximum, and minimum rut depths by sections (two modified asphalts and control section) are also shown in Table 19.

Transverse Pavement Profile

The profilograph records illustrated the actual profile of the pavement surface with reference to the straight profilograph beam. The outputs of the profilograph were reproduced by taking the coordinates of the profile at interval of 4 inches. Tables 1E through 9E in Appendix I show the coordinate system of the pavement profiles on the west-bound driving lane. Tables 1F through 9F in Appendix I show the coordinate system for the profiles on the west-bound passing lane. Similarly, Tables 10E through 18E and 10F through 18F in Appendix J show the coordinate system of the profile for driving and passing lanes on the east-bound lane.

The results of the post-construction differential leveling survey were reduced to the elevation of the position of the profilograph legs at the center and the edge of the lane and the steel pins at both ends of the pavement. The coordinates of the slope of the profilograph were derived from the elevation. From these coordinates of the profile and the profilograph elevation, the actual pavement profile were obtained. The coordinates of these profiles are shown in Tables 1G through 9G and 1H through 9H in Appendix K for the profiles on the west-bound driving and passing lanes. Similarly, the coordinates of the profiles of the east bound driving and passing lanes are shown in Tables 10G through 18G and 10H through 18H respectively in Appendix L.

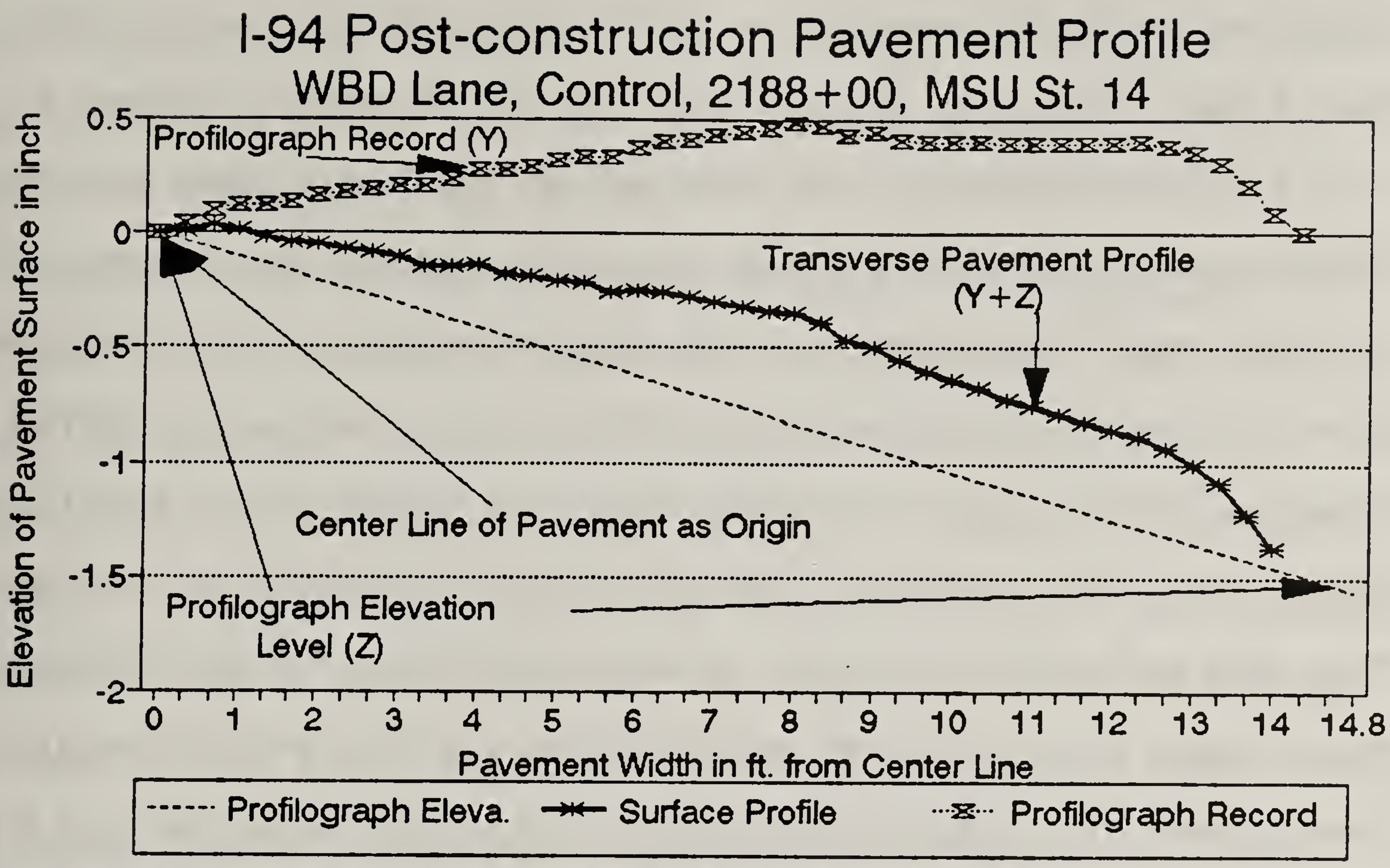
A typical post-construction pavement profile and elevation is shown in Figure 11a for driving lane and 11b for passing lane. The profilograph record (Y) in Figures 11a and 11b are the transverse pavement profile taken from the Rainhart profilograph. The profilograph elevation (level) (Z) is the differential level of the profilograph indicating the slope of the profilograph on the pavement surface. The actual transverse pavement surface is shown by the transverse pavement profile (Y+Z) in Figures 11a and 11b.

The actual profiles of the post-construction pavement at each section on the west-bound lanes were drawn and are shown in Figures 1C through 13C for the driving lanes and Figures 1D through 13D for the passing lanes in Appendix M. Similarly, the pavement profiles with respect to the slope of the profilograph for the east-bound lanes were drawn and are shown in Figures 14C through 26C for the driving lanes and Figures 14D through 26D for the passing lanes in Appendix N.

The post-construction pavement surface profile was smooth and sloped as intended for proper drainage (see Photo P). The smoothness of transverse slope of the post-construction pavement surface is seen in the typical profile and elevation of driving lane in Figure 11a and in Figure 11b for passing lane.

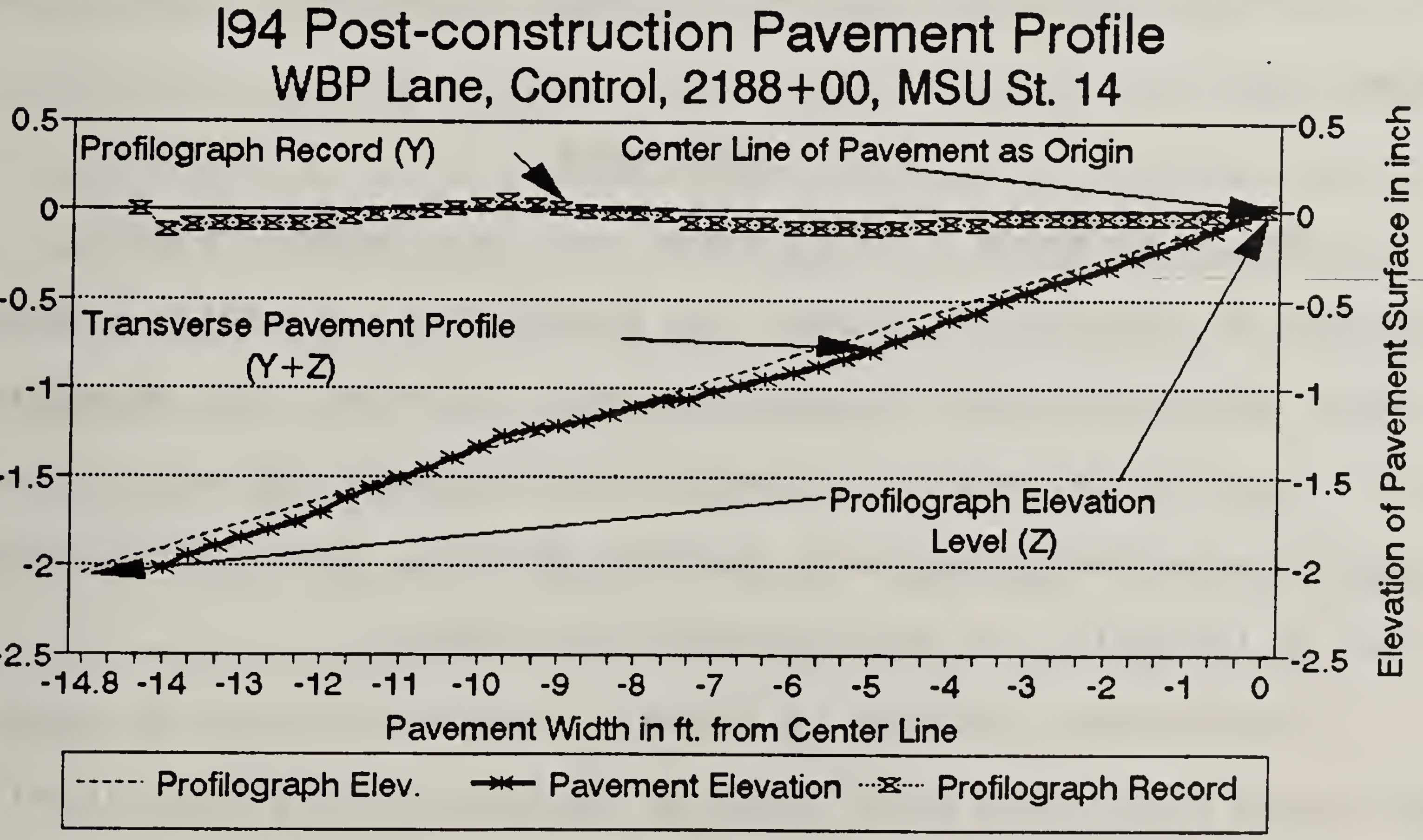
OBSERVATIONS

Bubbling of polymer modified asphalt were observed after



Note: Abscissa represents pavement width in ft.; ordinate represents pavement drop in inch.

Fig. 11a. Typical Post-construction Pavement Profile and Elevation of a Driving Lane



Note: Abscissa represents pavement width in ft.; ordinate represents pavement drop in inch.

Fig. 11b. Typical Post-construction Pavement Profile and Elevation of Passing Lane

break down roller compaction mat in both the Polybilt and Kraton modified asphalt pavement sections (see Photo Q). In addition, the first lift over the cracks with crack sealer caused a swelling phenomena of the PMBS after the break down rolling. These observations were made in all sections of pavement with and without modified asphalt, with the exception of the trenched areas of pavement, where the crack sealer had been removed. The passing lanes of the pavement were not trenched (milled) and there was crack sealing compound over the cracks on the pavement. The swelled materials were scraped off prior to the placement of the second lift. Another observation was the down time of the continuous drum type mixing plant. This had occurred due to the change of asphalt (from unmodified 85-100 Exxon to one of the modified asphalts or vice versa). Emptying the asphalt tank of the continuous drum mix plant to the storage tank and refilling the asphalt tank with appropriate modified asphalt required minor time loss.

CONCLUSION

The performance of a pavement can deteriorate rapidly because of premature rutting. The annual truck traffic, increased loads, different wheel configurations, increased tire pressures, and radial tires have accelerated the problems. Extreme climatic conditions as experienced in eastern Montana, have contributed to loss of integrity of the pavement even faster.

Conventional methods of asphalt concrete mix design were developed for single axle loads of 18 Kips, with conventional pressure of 70-90 psi. Adjustment of the components of a pavement are now required to strengthen the pavement for new conditions. Asphalt mixes modified with polymers are expected to offer a solution to rutting of pavements.

The pre-construction pavement surface conditions provided testimony of the extent of pavement deterioration. The drainage pattern on pavement surface have changed because of rutting. The Rainhart transverse profilograph is easy to use and produces a permanent record of the transverse surface profile. The frequency and severity level of transverse and longitudinal cracks with reference to the fixed stations, marked by the steel pins, depict the pre-construction and post-construction pavement surfaces. These fixed stations will provide a base for the future monitoring process.

The production and placement of polymer modified asphalt pavement was not significantly different than that for conventional asphalt binders. The asphalt can be modified locally in the refineries in the state. The identical compaction pattern for both unmodified and modified asphalt sections demonstrated that the modification does not require special efforts to obtain the specified level of compaction. Marshall stability and flow, unit weight, and percent air voids fell within the design specification. The field density of all modified and unmodified asphalt sections were within 95 to 98 percent of the target density.

The cost analysis showed that the cost of asphalt binder was only 0.74 percent of the total cost per ton of PMBS with about 5.5 percent of unmodified asphalt whereas they were 2.18 percent for Kraton modified asphalt and 1.37 percent for Polybilt modified asphalt. The life cycle cost of pavement should be considered to evaluate the impact of higher cost of modified asphalt. The higher cost of modified asphalt could be justified if the pavement performs better than the pavement with conventional asphalt. The result of the monitoring phase will provide this information.

The post-construction pavement surface of all three sections had similar profiles. The construction variables for the three sections were the same except for the mix and asphalt temperatures. All these sections should be subjected to similar future loading patterns and extreme climatic conditions.

The test sections will be monitored for a period of five years, with annual surveys each June. Subsequent progress reports and a final report will document and evaluate the performance of the Kraton and Polybilt modified asphalts.

References

1. Climatological Data Annual Summary, Montana 1990, Volume 93, No. 13.
2. Automatic Counters, 1990, Montana.
3. Traffic By Section Montana 1989
4. Distress Identification Manual for the Long-Term Pavement Performance Studies, SHRP-LTPP/FR-90-001, Strategic Highway Research Program, Washington D. C.
5. Wyoming State Highway Department Point of Rocks, Report No.1 V10., 1 May, 1988, DSK RDP 98(88-1637), Wyoming

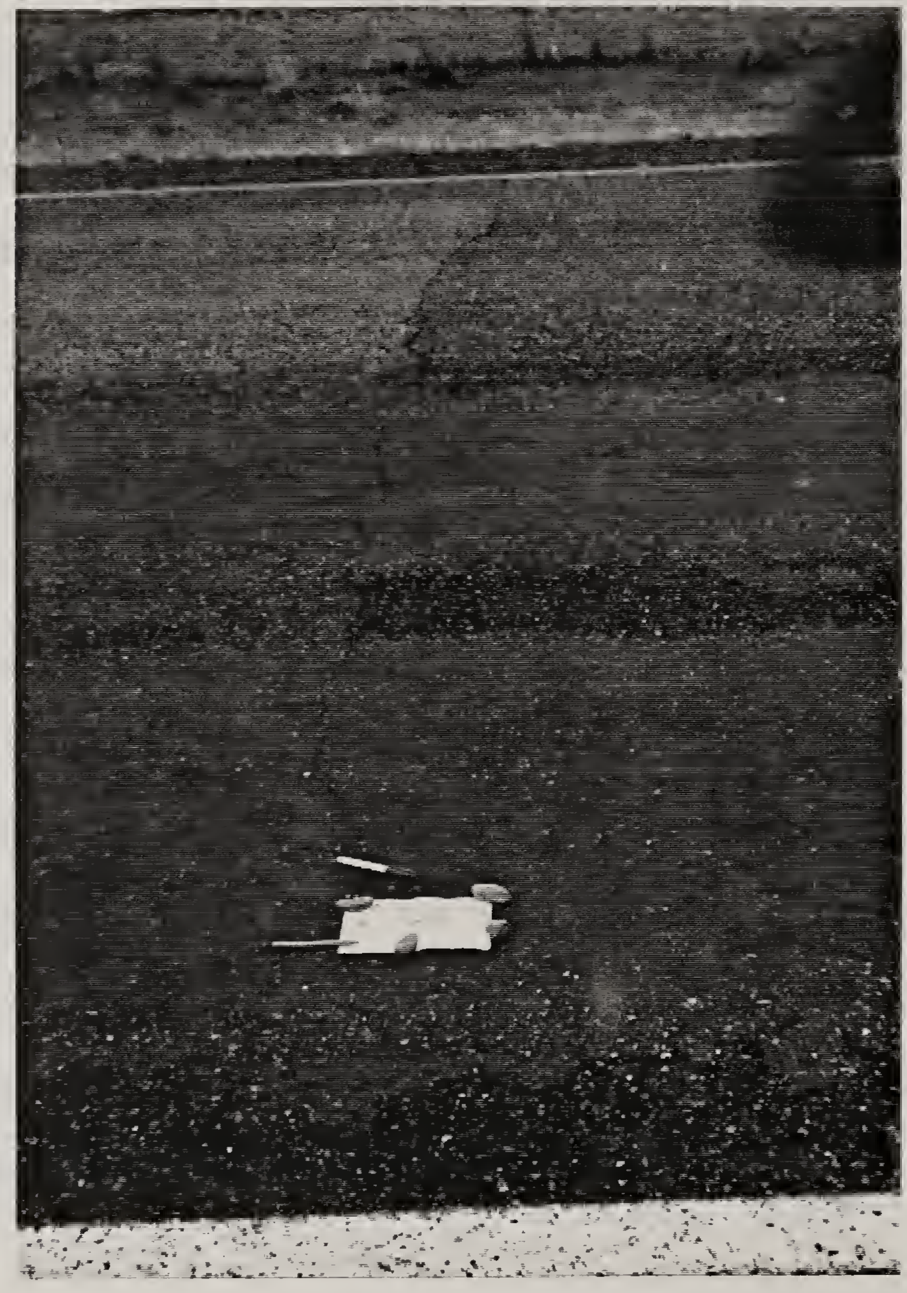


Photo A. Pre-construction Pavement Rutting and Bleeding

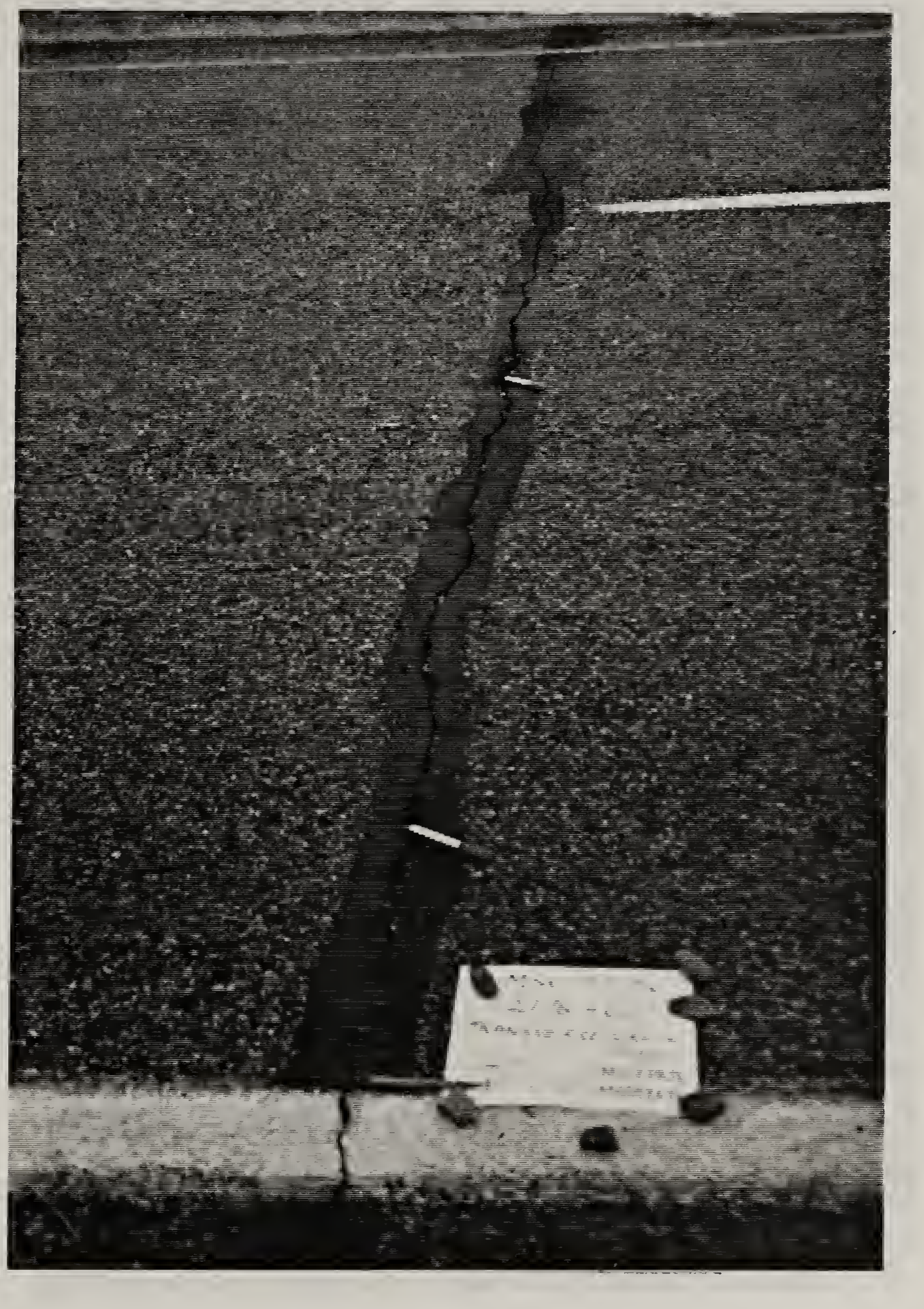


Photo B. Full Width Transverse Thermal Crack with Crack Sealing

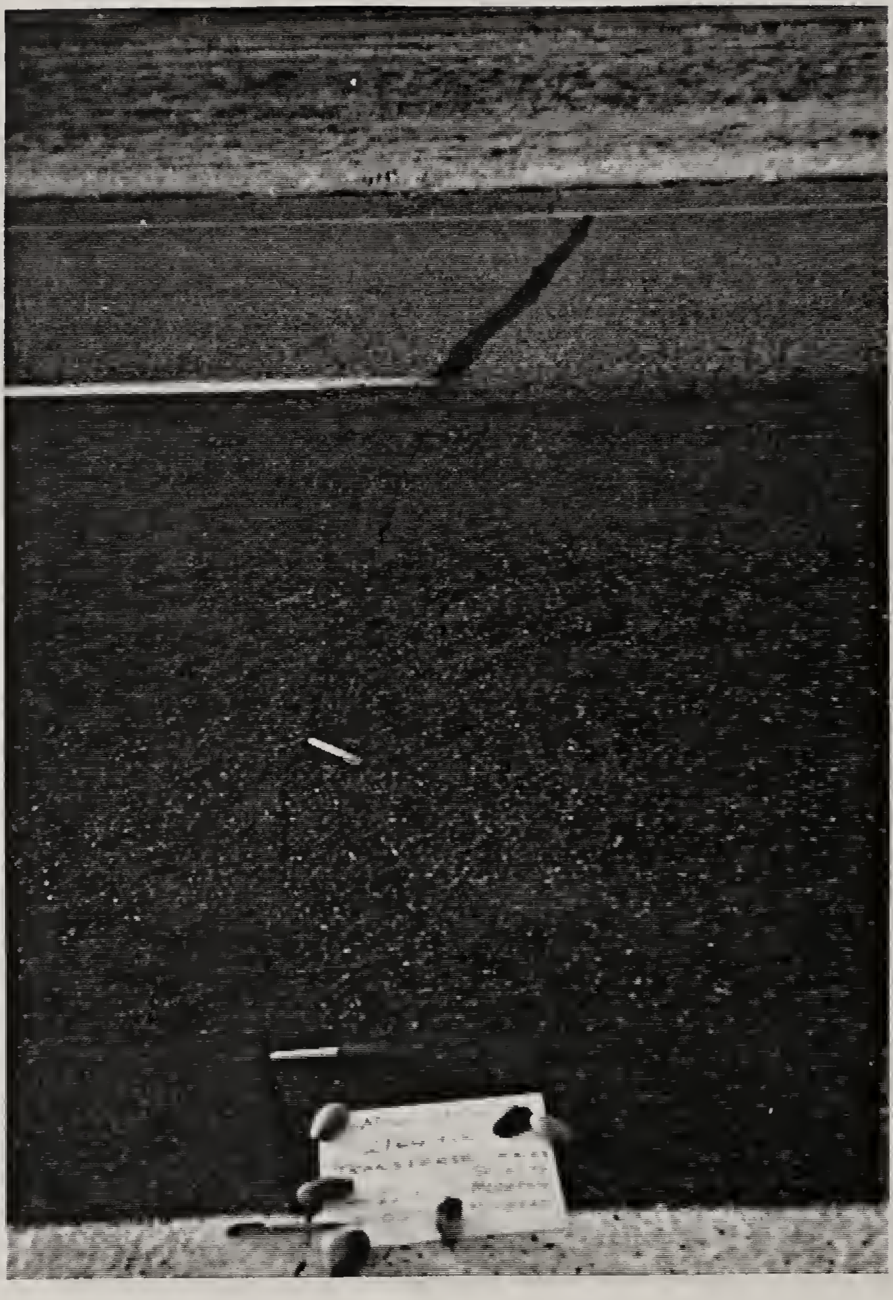


Photo C. Two Distinct Phases of Pre-construction Driving and Passing Lanes of Pavement Surface with Apparent Maintenance Work on the Driving Lane

Photo D. Position of the Steel Pins on Both Sides Pavement and Reference Bars by the Right-of-way Fence

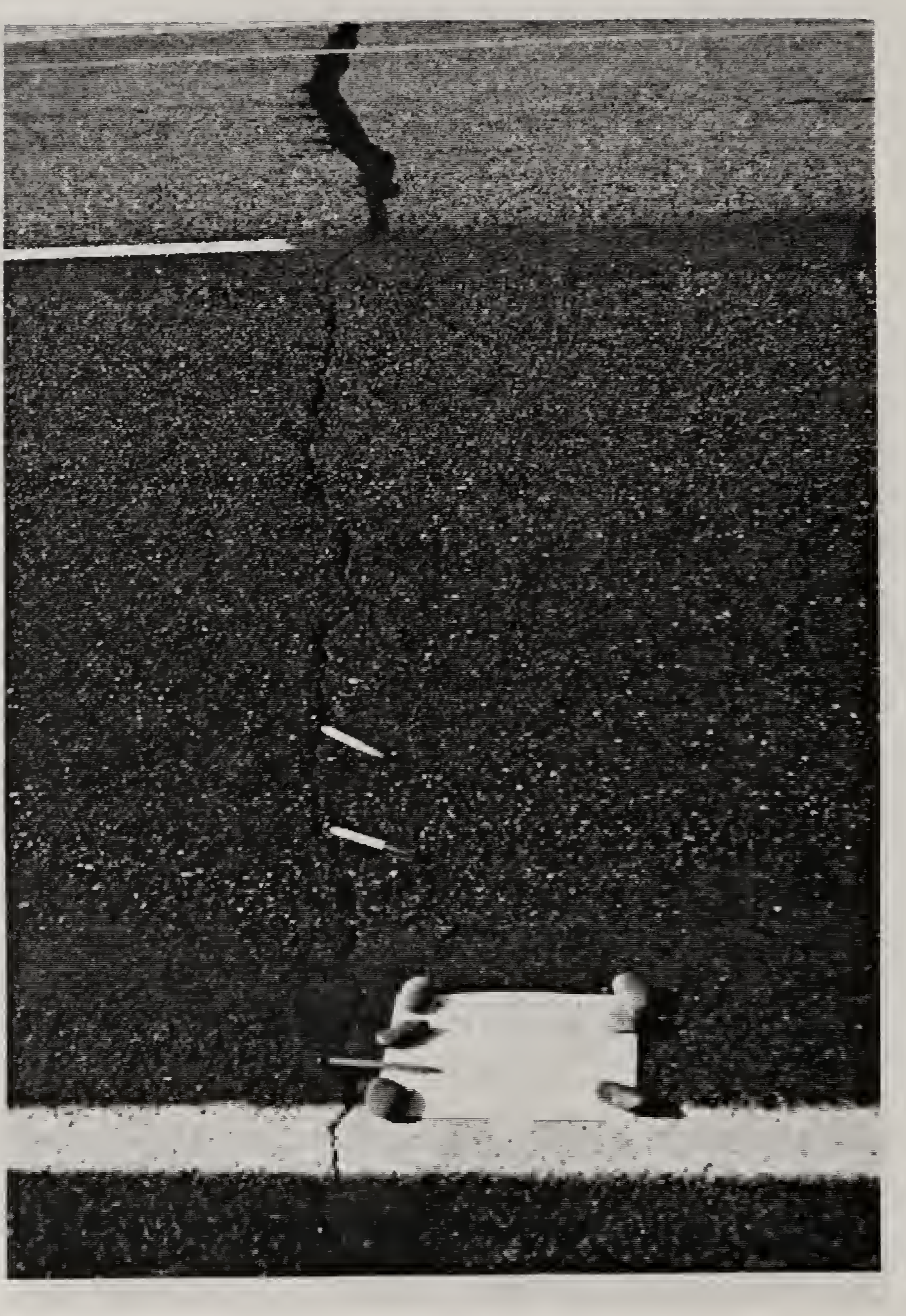


Photo E. Typical Transverse Crack

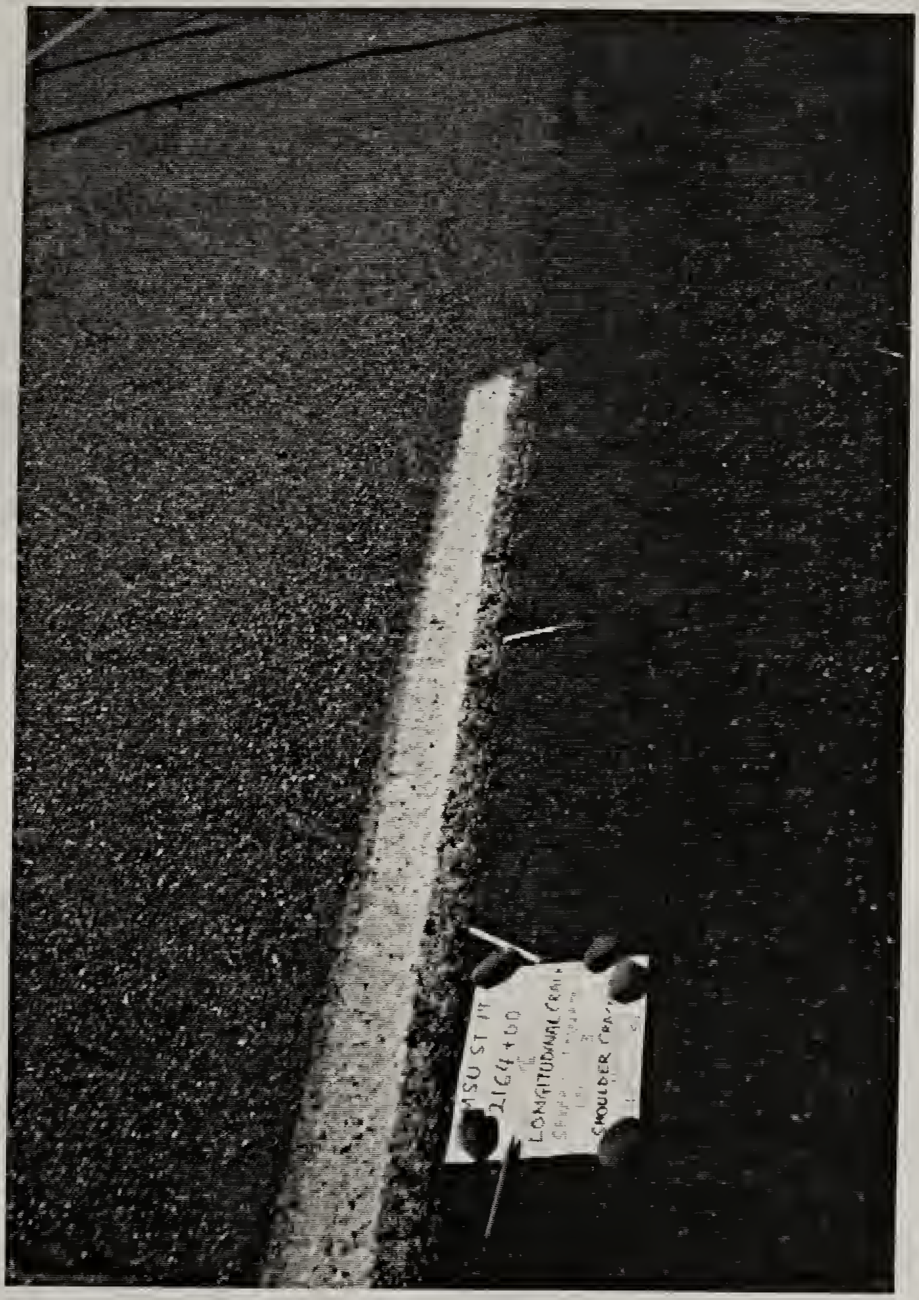


Photo F. Typical Longitudinal Crack

Photo G. Profilograph

Photo H. Polybilt Tanker

Photo I. Stationary Tank of Drum Type Continuous Bituminous Mix Plant

Photo J. Drum Type Continuous Bituminous Mix Plant

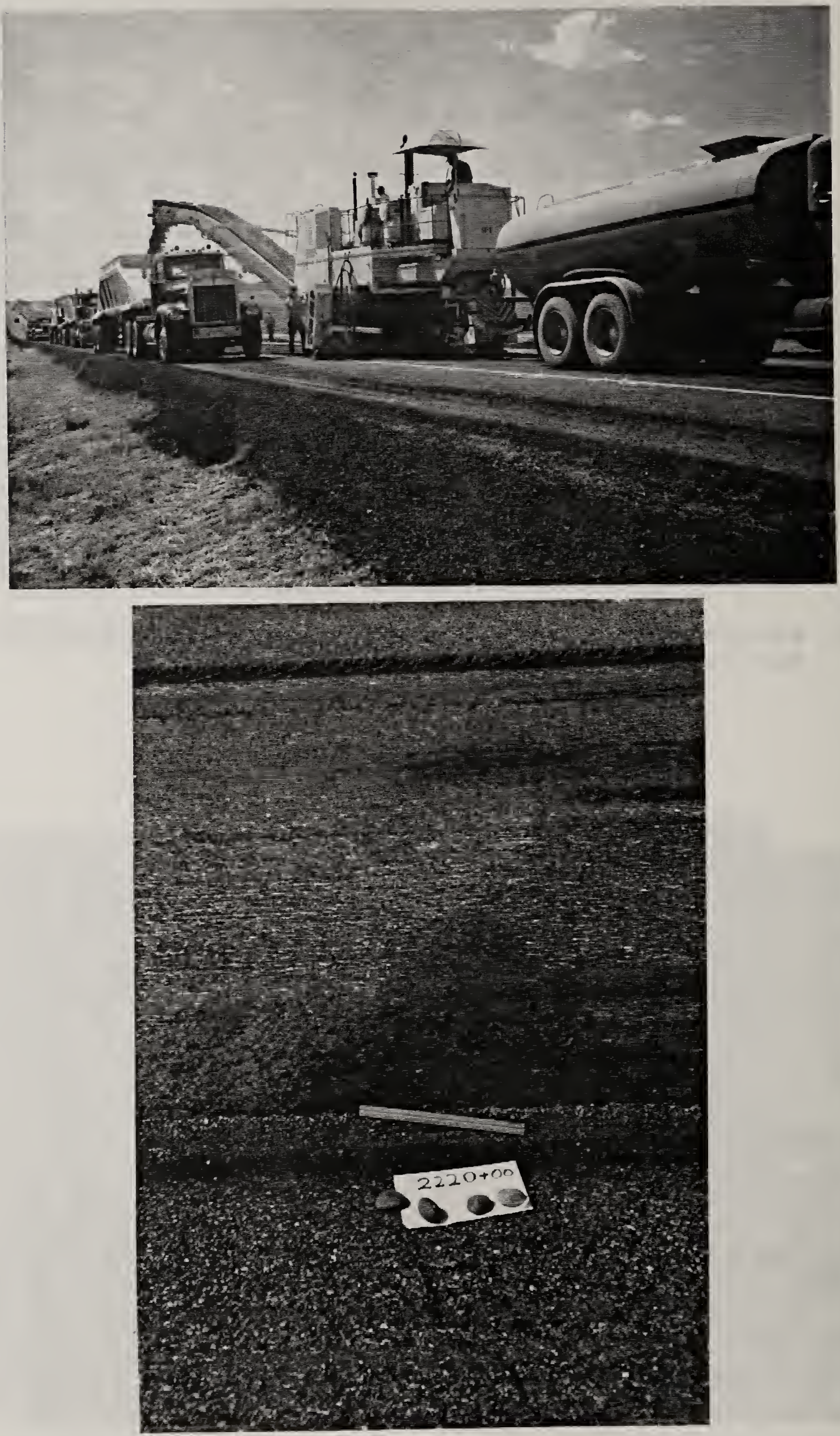


Photo K. Cold Milling Plant (Top) and a Trenched Section (Buttom)

Photo L. Dump Trucks and Paving Operation

Photo M. Paver in Operation

Photo N. Vibrating Rollers in Operation

Photo O. Finishing Steel Wheel Roller

Photo P. Post Construction Pavement Surface

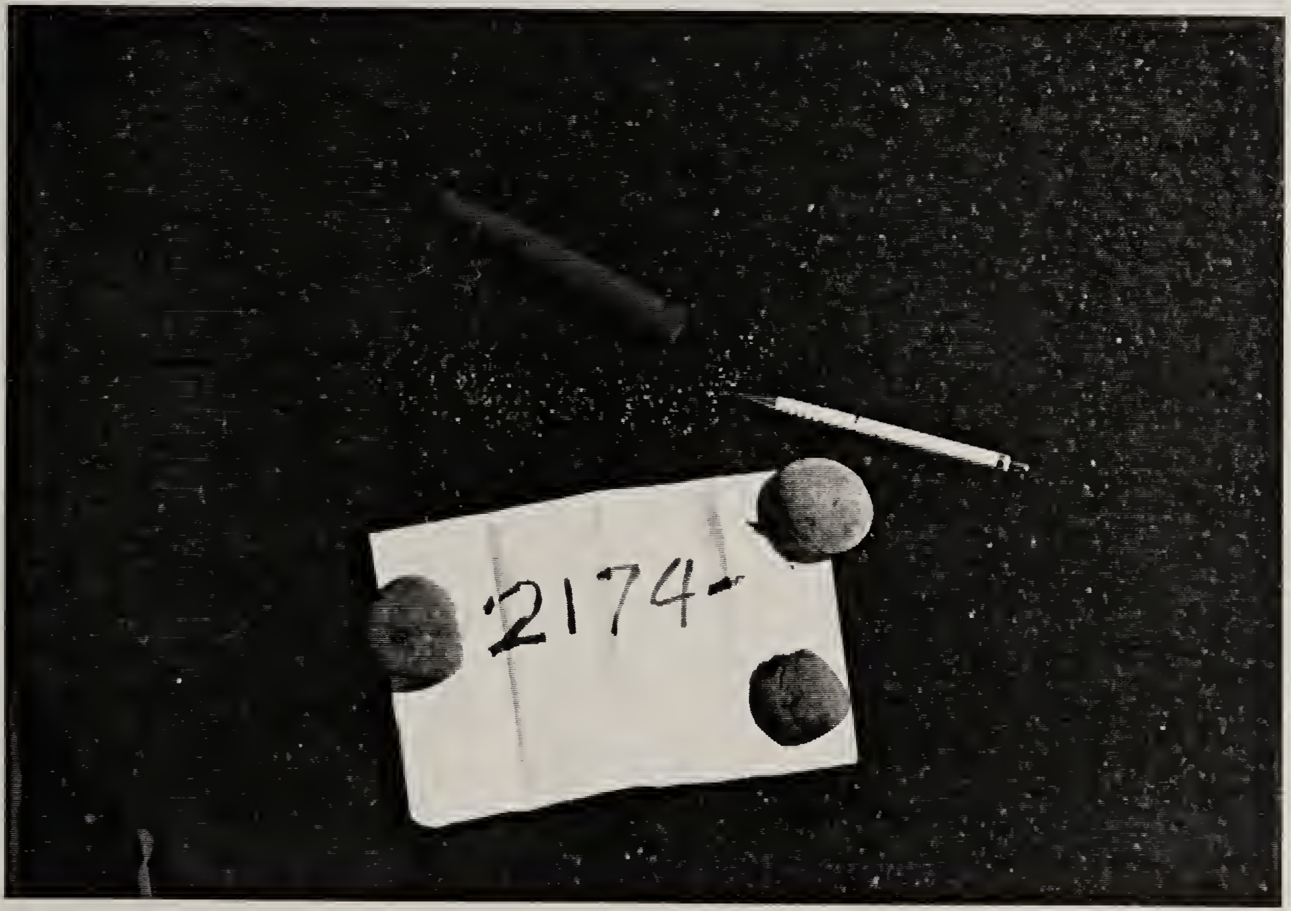


Photo Q. Bubbling of Polybilt and Kraton Polymer Modified Asphalt on the Break Down Roller Compacted Mat

Appendix A

- Special Provision of the Contract Document - Specification and Requirement of the Construction of the Overlay on the Experimental Test Sections Using Modified Asphalt

The pipe insert at Station 2242+36 will require the contractor to provide an opening in the pipe insert to allow the existing median inlet to drain runoff into the pipe. See Special Provision No 20.

D. Measurement of Payment

The bid item for insert culverts will be listed in the proposal as "Drainage Pipe Insert - 36 in. or 60 in." The Drainage Insert Pipe is always a steel pipe as long as it is an option. Therefore, the size, quantities, length, etc., for the Drainage Insert Pipe are the same as that for the steel pipe even though a different type may be used.

All costs for materials, handling, tools, equipment, and labor necessary to accomplish the work shall be included in the contract unit price bid per linear foot of the insert pipe as described above.

17. PLUG PIPE

As indicated on the plans (Culvert Frame) at Station 2226+45, the contractor shall plug the existing pipe. The contractor shall accomplish this work by dumping and compacting gravel at the pipe ends, as directed and to the satisfaction of the engineer.

All costs necessary to accomplish the above shall be paid for as Miscellaneous Work.

18. POLYMER-MODIFIED ASPHALT EXPERIMENTAL PAVEMENT TEST SECTIONS

This provision is for the construction of four experimental sections that incorporate modified asphalt and other sections of pavement that contain 85/100 AC. Two sections of the roadway are to be constructed using Kraton modified asphalt and two sections are to be constructed using Polybilt modified asphalt.

If the properties of one or both of the modified asphalts supplied to the project are not within the specifications or are otherwise not acceptable to the Engineer, the Department reserves the right to terminate part or all of the modified asphalt construction. If this is done, Grade B plant mix with 85/100 AC will be placed in those areas. The modified asphalt placed prior to said termination may be left in place or replaced using contract bid prices and items at the direction of the Engineer.

Materials

The product Kraton marketed by Shell Chemical Corporation and the product Polybilt marketed by Exxon Chemical Company will be used and no substitutions will be permitted. Names and phone numbers of product representatives are as follows:

Kraton	
John Stetz	(713) 241-7623
Polybilt	
F. R. (Fritz) Kyle, Jr.	(406) 657-5407

Base Asphalt

The contractor is responsible for procurement of the modifier and the base asphalt(s), and for pre-testing and reporting the base asphalt(s) properties. The contractor shall furnish certified test results for the base asphalt(s). The certified results reported shall include all of the following AASHTO tests: T-44 - Solubility; T-48 - Flash; T-49 - Penetration; T-51 - 77°F Ductility; T-102 - Spot Test; T-179 - Thin Film Oven Test; and T-201 -Kinematic

Viscosity.

Each modifier supplier must certify the base asphalt is compatible with the said modifier before asphalt from that source is approved for use on the project.

Modified Asphalt

The contractor is responsible for blending and delivering the modified asphalt to the project.

A report must accompany each load of modified asphalt delivered to the project that certifies by applicable test results that the load of modified asphalt conforms to the specifications. A copy of these test results shall be given to the Engineer. Modified asphalts shall be certified to be storage-compatible with the base asphalt by the polymer supplier.

The modified asphalt supplied to the project and sampled from the discharge line to the mixing plant shall comply with the following tables of specifications. The contractor shall provide an acceptable sampling device and take samples when directed and witnessed by the engineer.

Kraton Modified Asphalt

Test	Required Value	Test Method
Viscosity, cst, 275°F	1000 minimum	AASHTO T201
Penetration, 77°F, 5 sec., 100 g	70 minimum	AASHTO T49
Penetration, 39.2°F, 60 sec., 200 g	35 minimum	AASHTO T49
Ring & Ball Softening Point, °F	160 minimum	AASHTO T53
Ductility, 77°F	80 minimum	AASHTO T51
Ductility, 39.2°F	76 minimum	AASHTO T51
Flash Point COC Min. °F	425	

Polybilt Modified Asphalt

Test	Required Value	Test Method
Viscosity, cst, 275°F	400 minimum	AASHTO T201
Viscosity, Poise	1000 minimum	AASHTO T202
Penetration, 77°F, 5 sec., 100 g	80 minimum	AASHTO T49

Penetration, 39.2°F, 60 sec., 200 g	30 minimum	AASHTO T53
Ring & Ball Softening Point, °F	130 minimum	AASHTO T51
Ductility, 77°F	40 minimum	AASHTO T48
Flash Point COC Min. °F	425	

Construction

The contractor shall construct the project so the sections identified as containing modified asphalt or 85/100 AC contain only that which is what is specified. This includes to fill for the respective milled section of roadway.

The contractor will be required to shut down and empty his drum and surge bin before any change in asphalt types. The placement of the asphalt paving mixtures shall be as follows:

Length of Each Section	Station	thru Station	Asphalt
7900 ft.	1940+00	2019+00 EB	85/100
5950 ft.	2019+00	2078+50 EB	Kraton Modified
7250 ft.	2078+50	2151+00 EB	85/100
5950 ft.	2151+00	2210+50 EB	Polybilt Modified
8372 ft.	2210+50	2294+22 EB	85/100
7900 ft.	1940+00	2019+00 WB	85/100
5950 ft.	2019+00	2078+50 WB	Polybilt Modified
7250 ft.	2078+50	2151+00 WB	85/100
5950 ft.	2151+00	2210+50 WB	Kraton Modified
8372 ft.	2210+51	2294+22 WB	85/100

The contractor will have a beginning and ending tolerance of plus or minus 100 feet on the placement of the asphalt paving mixture.

The contractor may sequence his work according to any one of three options: (1) he may pave successive lifts the full length of the project; (2) he may pave segments, bringing up each section to grade before he proceeds to the next section; or (3) he may submit his own plan which is subject to the approval of the Engineer. Paving shall be according to all applicable specifications.

The contractor shall have at least three asphalt storage tanks on the project which are suitable for use with the straight asphalt and the two modified asphalts. It will be the contractor's responsibility to have the modified asphalt suppliers inspect the tanks before any asphalt is stored in them. The contractor will remove all contaminants identified by the supplier and have the tanks reinspected before asphalt is stored in them.

The tanks shall be connected to the mixing plant to permit positive control of feed and to prevent back flow or other contamination of the other tanks.

Storage of Modified Asphalt

The modified asphalt shall be stored according to the recommendations of the modifier supplier. It shall be circulated or agitated for a minimum of one hour per day to insure uniformity. Storage temperature shall not exceed 350°F. If idle periods exceeding 72 hours are experienced, storage temperature shall be reduced to 325°F or below. Heating systems shall not operate unless circulation or agitation of the tank is maintained and the heating elements are completely covered with asphalt.

A representative of each polymer manufacturer shall be on the project during the initial three days of full production of each product for consultation, should problems arise with that product.

The contractor shall work closely with the representatives of the modifier suppliers, and shall comply with their recommendations concerning methods of production and placement of all the specified hot plant mix bituminous pavement for the test sections.

This shall not waive the Engineer's authority as defined in Article 105.01 of the Standard Specifications.

Measurement and Payment

The accepted quantities of the modified asphalt will be paid for at their respective contract unit price per ton. Said price and payment shall include all storage, handling, and other charges; all materials, tools, equipment, labor and performance of all work necessary or incidental to the furnishing, delivering, heating, hauling, manipulation, and application of the bituminous material unless otherwise expressly provided for. Any costs for the required project visit representative by the polymer manufacturer shall be included in the modified asphalt cost. The contractor will be paid only for modified asphalt actually incorporated into plant mix prior to a termination order. Modified asphalt being produced or in transit or stored on or off the project will not be paid for if the construction with polymer modified asphalt is terminated by the Engineer. The department will not pay for modified asphalt that is not placed in the properly designated areas.

Payment will be made under:

Pay Item	Unit of Measure
Kraton modified asphalt	per ton
Polybilt modified asphalt	per ton

Removal Sections

Modified asphalt sections that the Engineer orders removed will be paid at the contract bid prices for items of work required. The plant mix removed shall become the property of the contractor.

19. CONTRACT TIME - PROCEED DATE

A. General

This provision will modify and supplement provisions of Article 108.02 of the Standard Specifications.

B. Notice to Proceed

The notice to proceed will become effective no later than the date of May 6, 1991 after the award of contract. The contractor will have the option of setting, before the above specified date, a single date on which the notice to proceed will become effective.

The contractor shall submit the selected effective date to the engineer, in writing, not more than 15 days after award of contract.

Appendix B

- Project Proposal for Monitoring and Construction

Development of Implementation Plans for a Field Experimental Project With Pavements Utilizing Asphalt Modifiers

PROPOSAL

Submitted to

Montana Department of Highways

by

Joseph D. Armijo, P.E.
Department of C/AE
Montana State University
Bozeman, MT 59717

June 30, 1989

INTRODUCTION

In pursuit of solutions to problems of rutting and cracking of asphalt pavements, the Montana Department of Highways contracted with the Department of Civil and Agricultural Engineering of Montana State University to investigate asphalt modifiers. During the interval, July 1, 1988 to April 1, 1989, laboratory testing was performed on asphalt cement 120-150 grade samples from the four Montana refineries, modified with six separate commercial modifiers. Results of the testing were submitted to MDOH and summarized at the District Engineers' Meeting in Helena on May 16, 1989.

Following the DE meeting and subsequent discussions, the MDOH requested this proposal to develop an implementation plan to field test modified asphalts in pavement sections. Results of the laboratory testing provided direction to pursue in establishing the field test sites.

The following pages contain a concise description of objectives of this proposal, a time schedule, and a budget estimate. In addition, methods and personnel availability will be discussed.

OBJECTIVE

The objective of this proposal activity is to develop an implementation plan that will be used in establishing an experimental project, utilizing asphalt modifiers. The plan will provide detailed recommendations, and plans - specifications - special provisions for construction of pavement test sections.

Modifiers, Kraton-Shell and Polybilt-Exxon, selected in the evaluation study, will be stipulated and described for use in an overlay project. The project will be on Interstate highway, preferably in the Yellowstone Valley where rutting has been extensive. (Yellowstone aggregates were used in the evaluation study). Asphalt type will be selected by the contractor. It is envisioned that the contract will be major in size, i.e. 10 miles; and that it will be divided into 3 parts of standard asphalt pavement and two modified pavement sections. The implementation plan will emphasize that normal construction practices will be used to the extent possible.

The other objective of the proposal's implementation plan is to establish procedures for monitoring the project. Monitoring will include construction, original condition surveys, and post construction surveys at specified intervals for a period of five years. The project, to be constructed in the 1990 season, will be closely scrutinized to determine differences in construction requirements that are different from those of a normal pavement.

METHODS AND PROCEDURES

As with any plans and specifications, a commitment to completeness is imperative. To assure that all bases are covered, the major source of information will be from the experience of others. Two sources, other agencies and additive manufacturers, will be contacted and gleaned for information that exists from previously constructed modified-asphalt test sites. Other highway agencies, particularly the Wyoming Highway Department, have expressed a willingness to share information. Wyoming, according to Materials Engineer, Tom Atkinson, has progressed to the state of establishing a ten mile experimental project west of Rawlins. The project will use generic specifications based upon desired performance properties of modified asphalts. Wyoming's initial field evaluation study, comprised of short test sections similar to the Big Timber study, has two years of results for review.

The other information sources, representatives of modifier manufacturers, are eager to assist Montana in establishing test sections. While evaluation and engineering judgment of this information will be the responsibility of the researchers, input from MDOH materials personnel will be sought.

Some on-site visits to existing test pavements, preferably under construction, may be valuable to observe methods and characteristics of site selection. However, this should not present a costly item since sites are available in Wyoming. The Rawlins-west project will be unde construction through summer of 1989. Personnel will be queried as to the effectiveness of the jot specifications and provisions for that project.

Monitoring of the project will consist of three phases, during construction, immediately following, and post construction surveys. During construction, observations will include extensive photography of operations. Methods of equipment will be noted and any special deviations from normal paving operations will be detailed, i.e. mixing requirements, laydown temperatures, rolling effort and patterns.

Following construction, original conditions will be surveyed to determine pre-traffic rutting and surface conditions. While overall conditions will be noted, rutting measurements will be done at selected locations. String-line and leveling techniques will be used at referenced transect locations. The number of transects will be sufficient to adequately represent the condition of the test section. Again photographs will be utilized as well as established pavement management techniques for assessing surface conditions.

For a period of five years after construction, monitoring of the experimental project will be done completely at a fixed time each year, preferably in late August. Rutting measurements will be taken at this time. An overview inspection (no rutting measurements) will be done in February in event that cold temperatures may be affecting the pavements.

An annual interim report will be submitted to MDOH and discussed to assure dissemination of information. In addition, an interim report will be submitted following construction to convey information and experience obtained during construction. At the end of five years, a final report and evaluation, with recommendations, will be compiled and submitted.

PERSONNEL

Organization and supervision of this implementation planning will be done by Joe Armijo, PE and Associate Professor of Civil Engineering. Background information on Armijo can be reviewed in the previous modifier study proposal. Similarly, graduate student Murari Pradhan will again provide much of the effort. Although Murari has completed his M.S. in Industrial and Management Engineering, he plans to obtain an M.S. in Civil Engineering before returning to his supervisory position in the Roads Department of Nepal.

Time Schedule

Depending upon the time necessary to approve this proposal, a start date of July 3, 1989 is assumed.

JULY			AUGUST			
3	17	24	1	7	15	25
Review and evaluate other agencies, plans, specs, prov. Same with commercial representatives			Visit Wyo. Project. Select Montana Overlay Project	Compile results and recommendations Finalize plans specs, prov.		Submit Report

1990

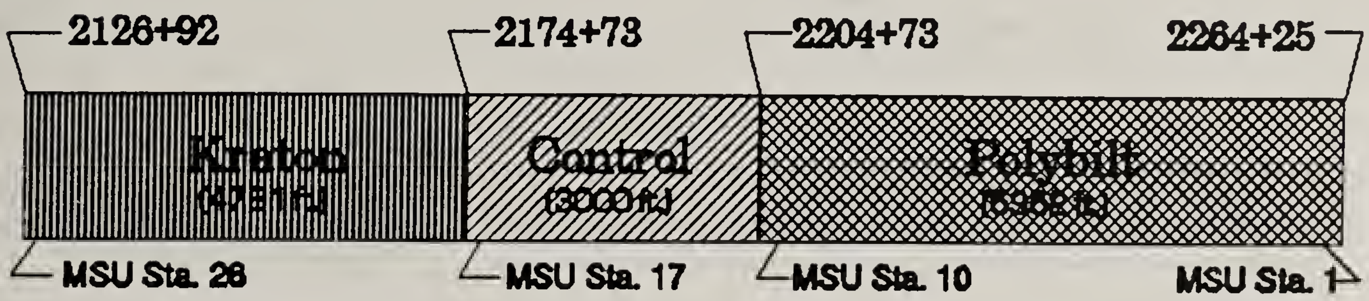
Summer - Construction Monitoring and Report

1991-1995

February	2 days field inspection 2 days documentation and report
August	1 week field surveys 1 week compiling data 2 weeks evaluation and Interim Report

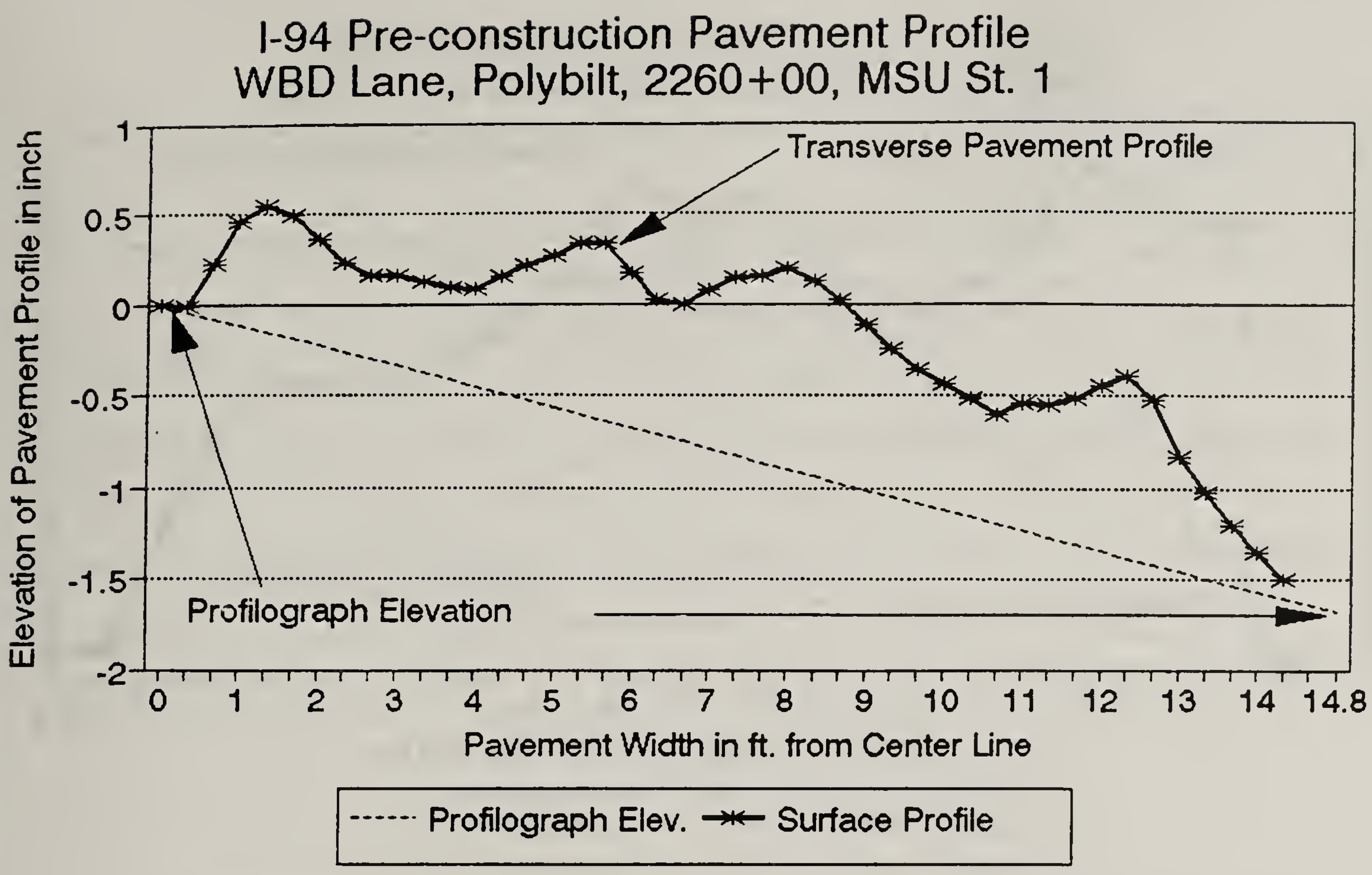
Appendix G

- Figures 1A through 13A - Pre-construction Pavement Profile and Elevation of West Bound Driving Lane
- Figures 1B through 13B - Pre-construction Pavement Profile and Elevation of West Bound Passing Lane



West Bound Interstate Highway I-94

MSU Station Number	Highway Station	Section by Binder Used
1	2260+00	Polybilt
2	2254+00	Polybilt
3	2250+00	Polybilt
4	2244+00	Polybilt
5	2238+00	Polybilt
6	2232+00	Polybilt
7	2226+00	Polybilt
8	2220+00	Polybilt
9	2214+00	Polybilt
10	2208+00	Polybilt
11	2200+00	Exxon
12	2196+00	Exxon
13	2192+00	Exxon
14	2188+00	Exxon
15	2184+00	Exxon
16	2180+00	Exxon
17	2176+00	Exxon
18	2170+00	Kraton
19	2164+00	Kraton
20	2160+00	Kraton
21	2154+00	Kraton
22	2150+00	Kraton
23	2144+00	Kraton
24	2138+00	Kraton
25	2134+00	Kraton
26	2130+00	Kraton



Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section

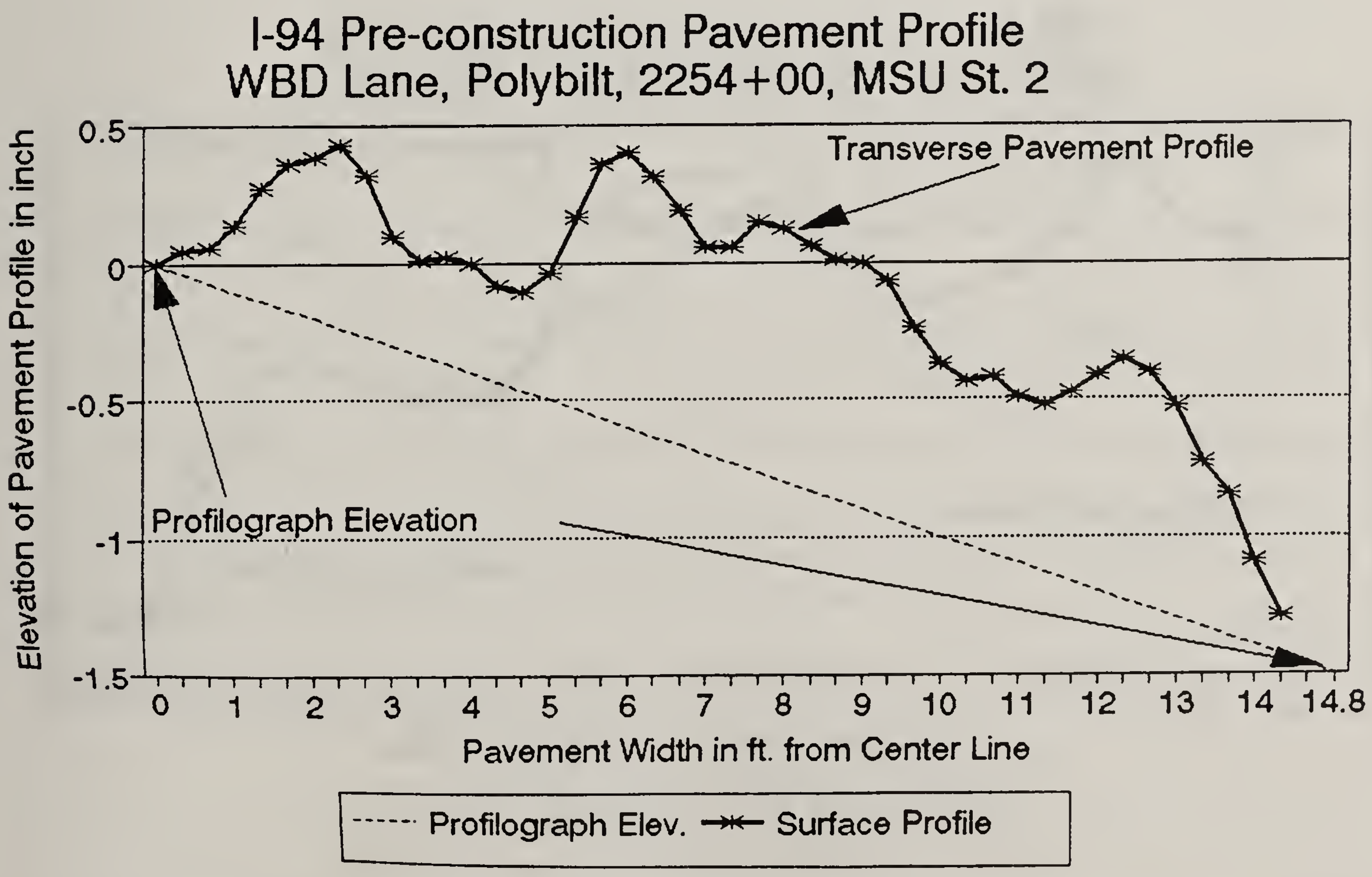
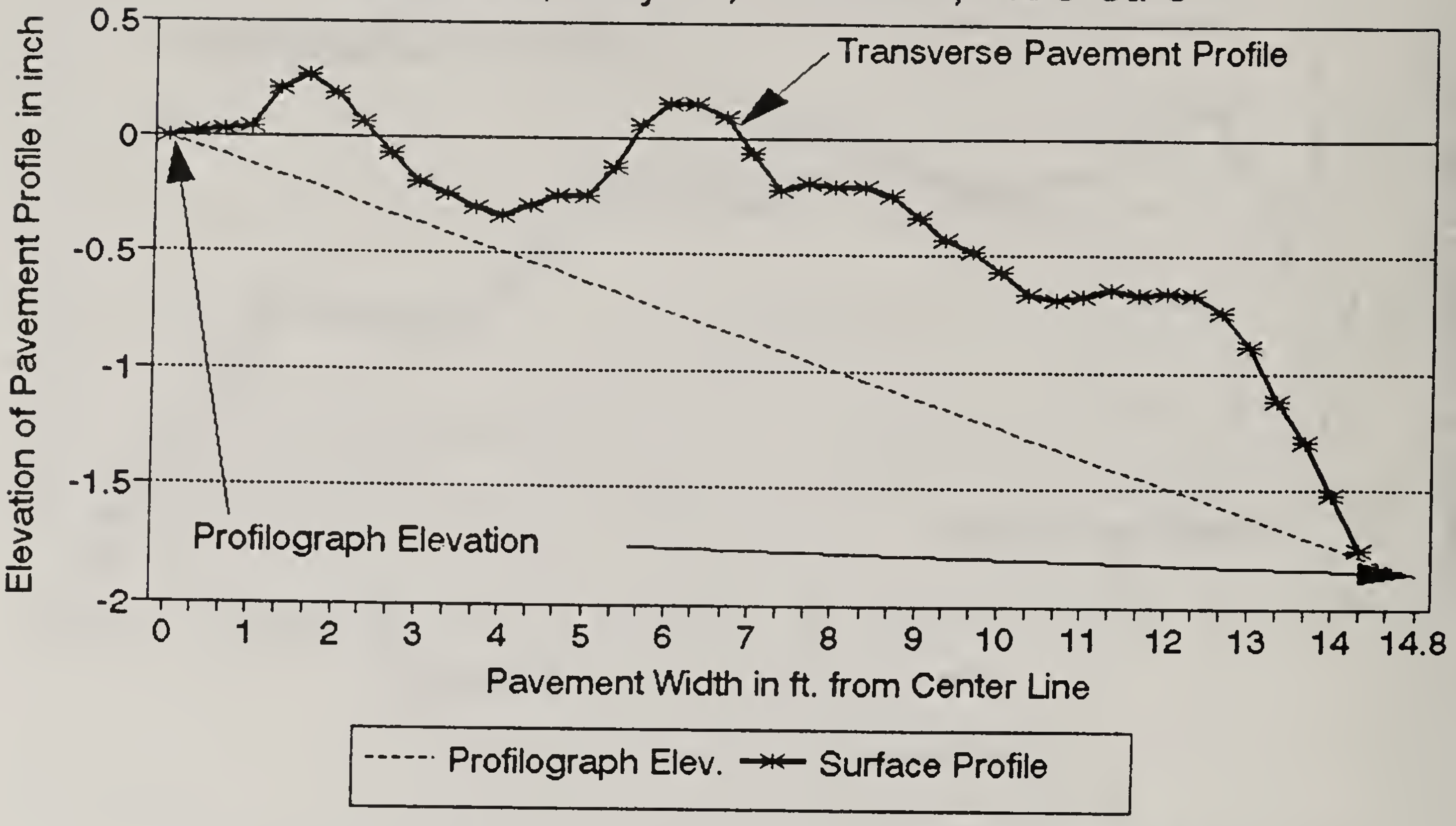
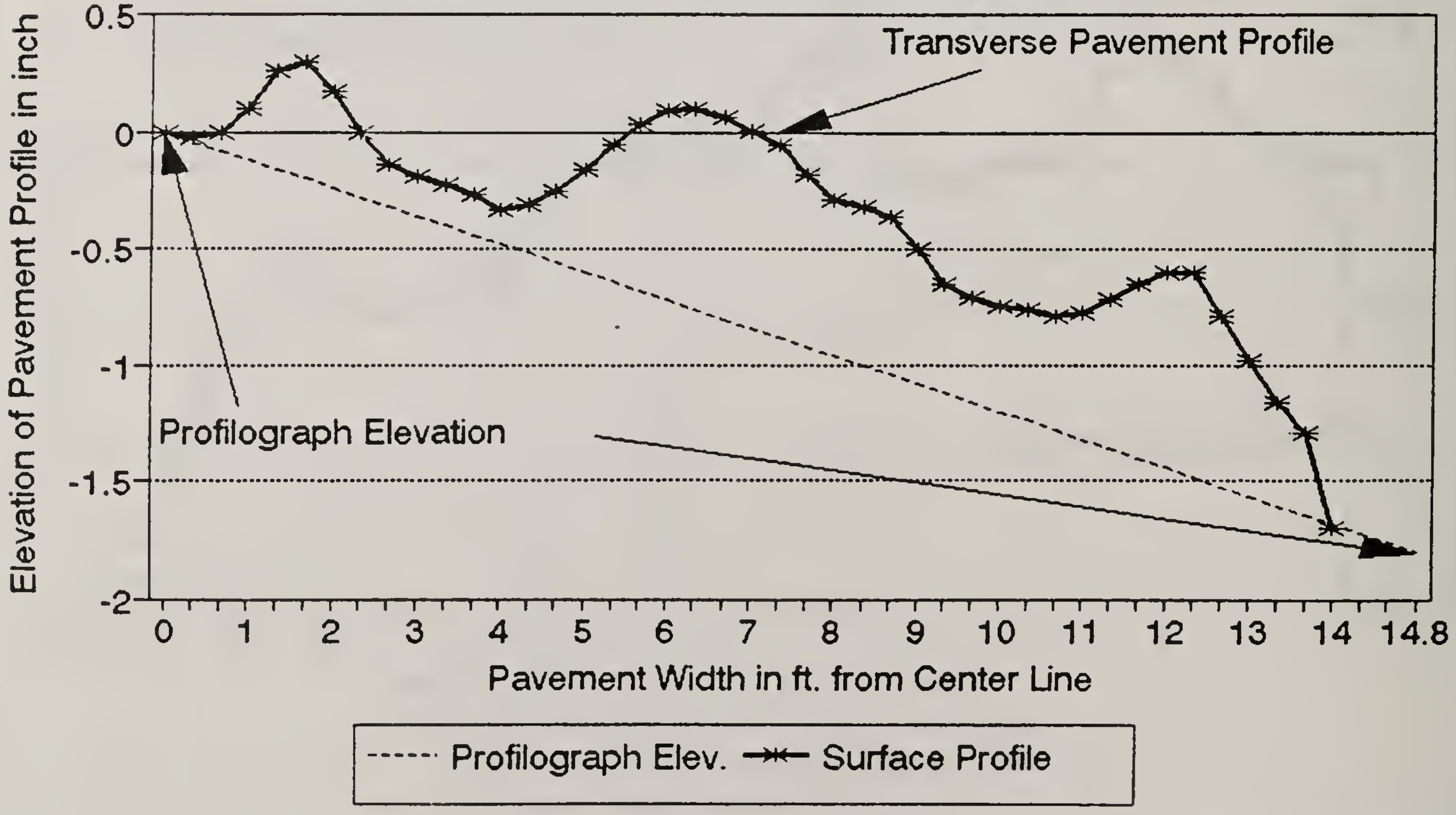


Fig. 1A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



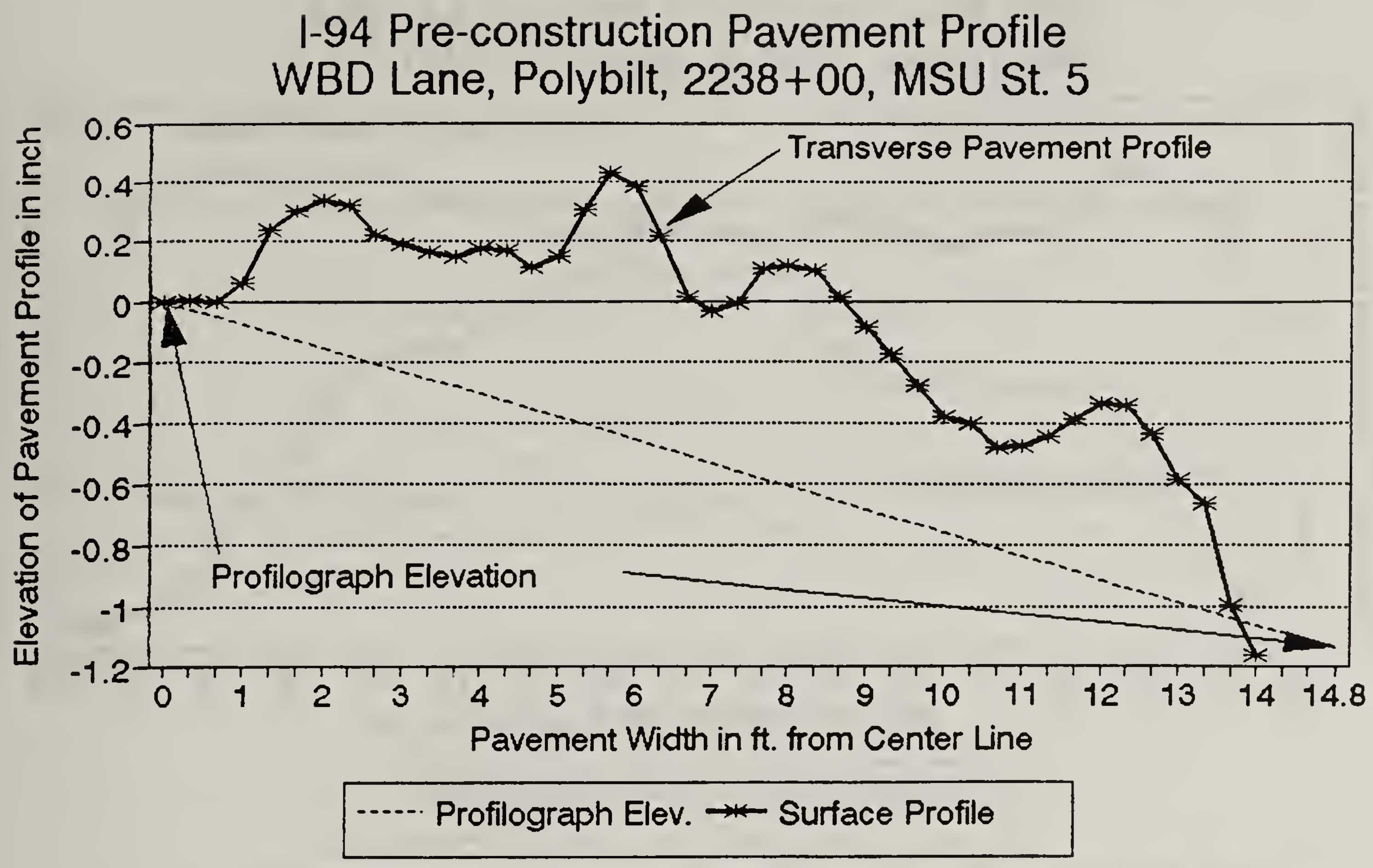
I-94 Pre-construction Pavement Profile
WBD Lane, Polybilt, 2250+00, MSU St. 3

Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section



I-94 Pre-construction Pavement Profile
WBD Lane, Polybilt, 2244+00, MSU St. 4

Fig.2A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Pre-construction Pavement Profile
WBD Lane, Polybilt, 2238+00, MSU St. 5

Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section

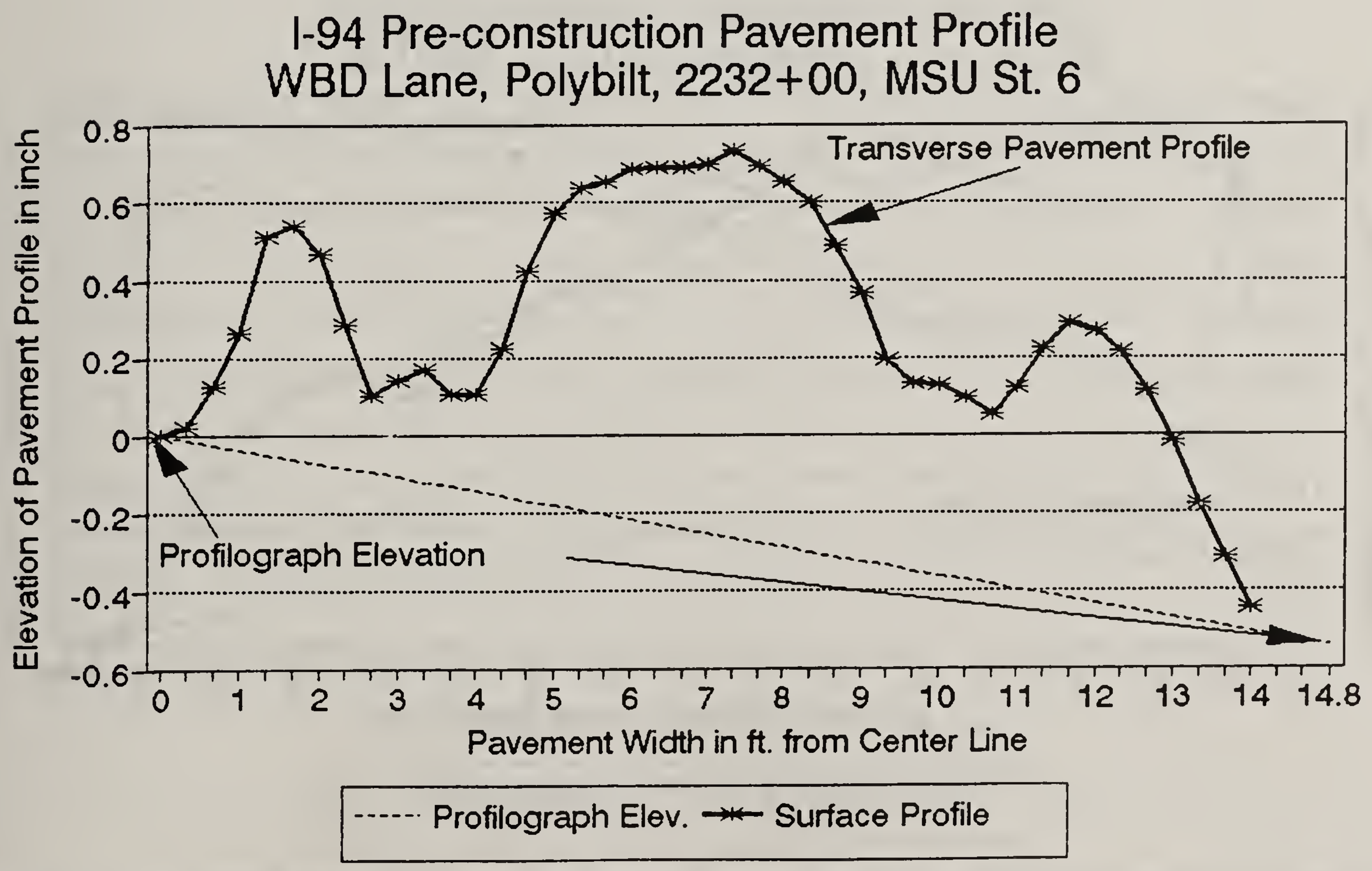
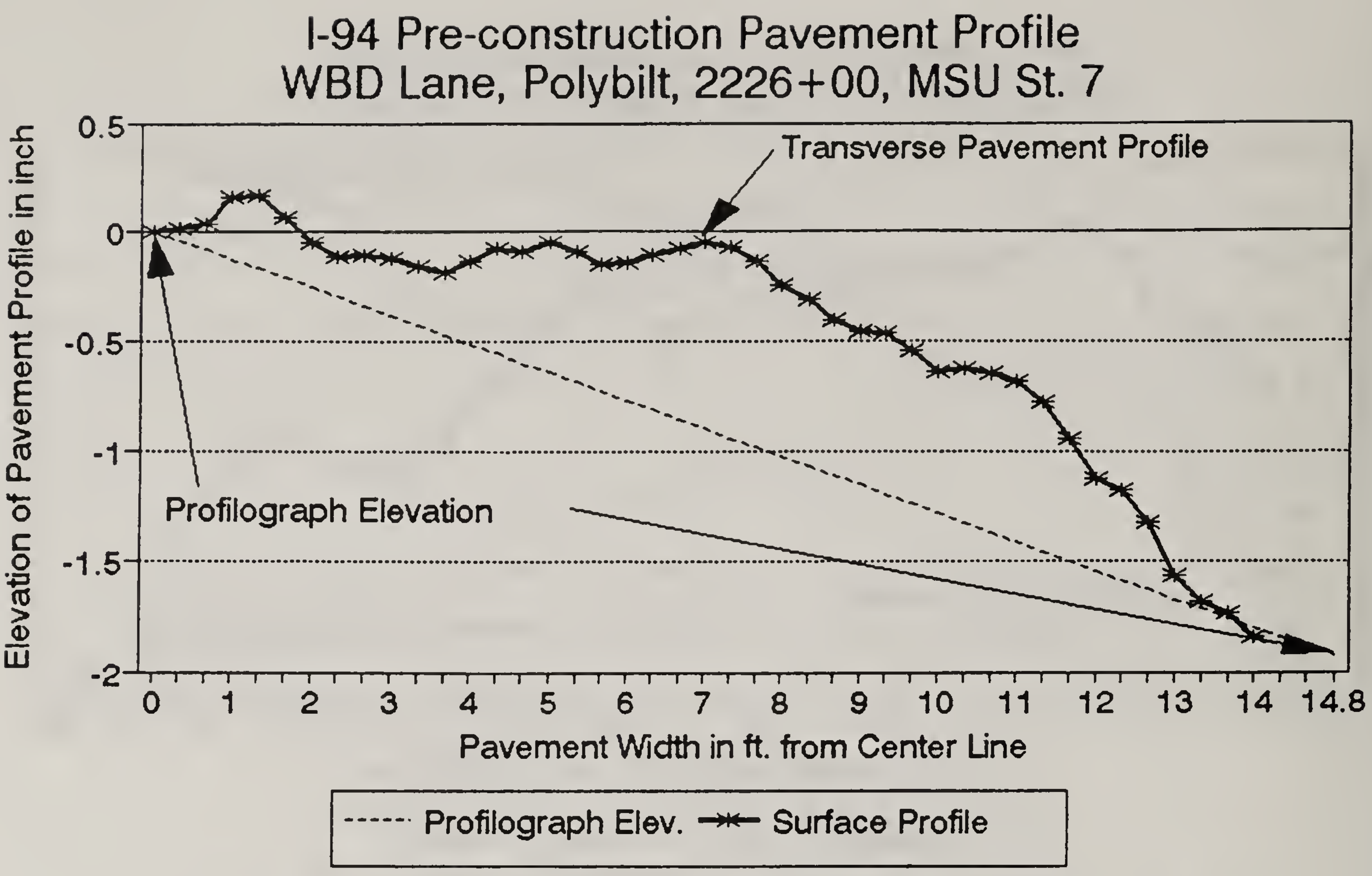
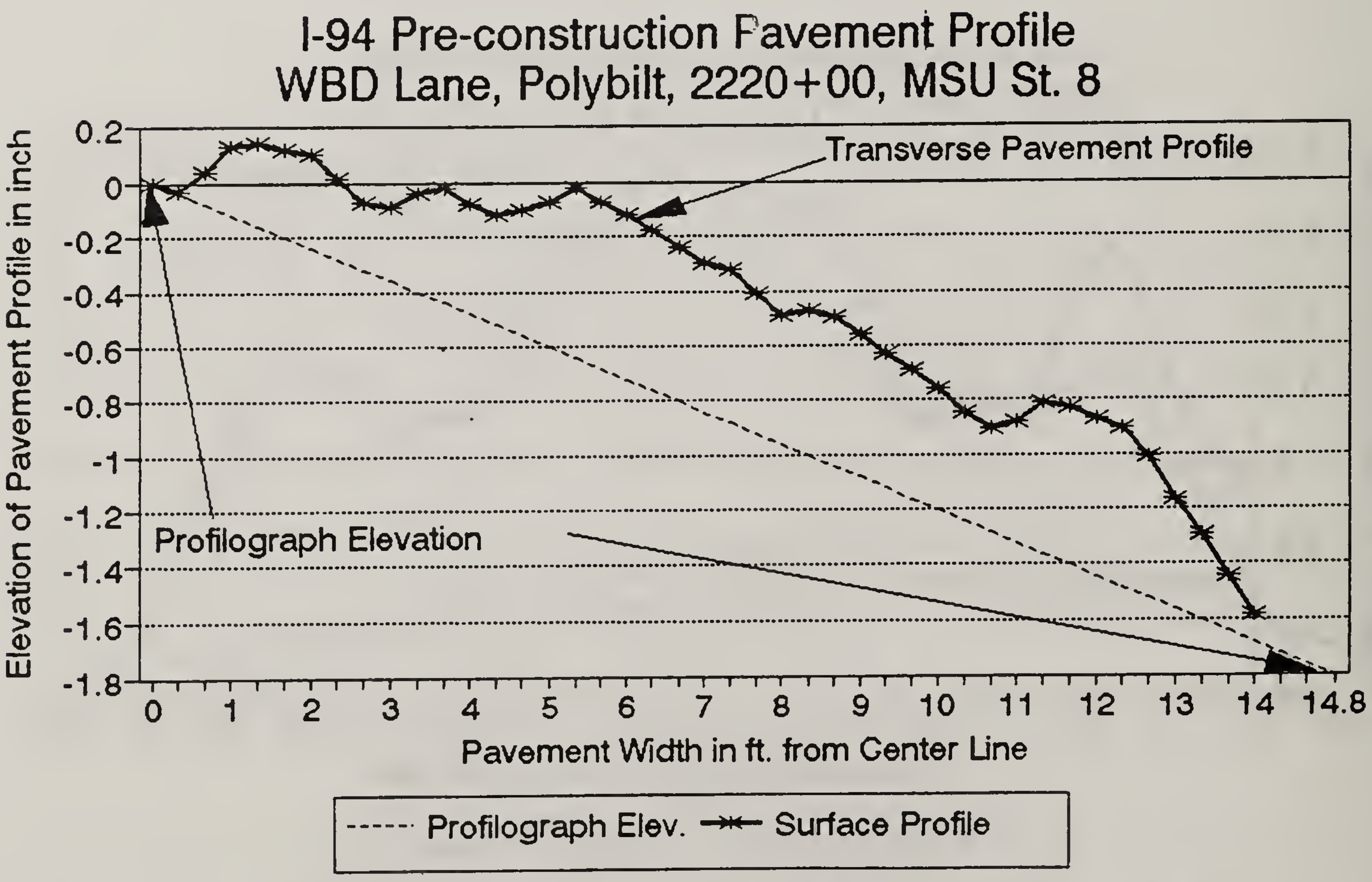

I-94 Pre-construction Pavement Profile
WBD Lane, Polybilt, 2232+00, MSU St. 6

Fig. 3A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



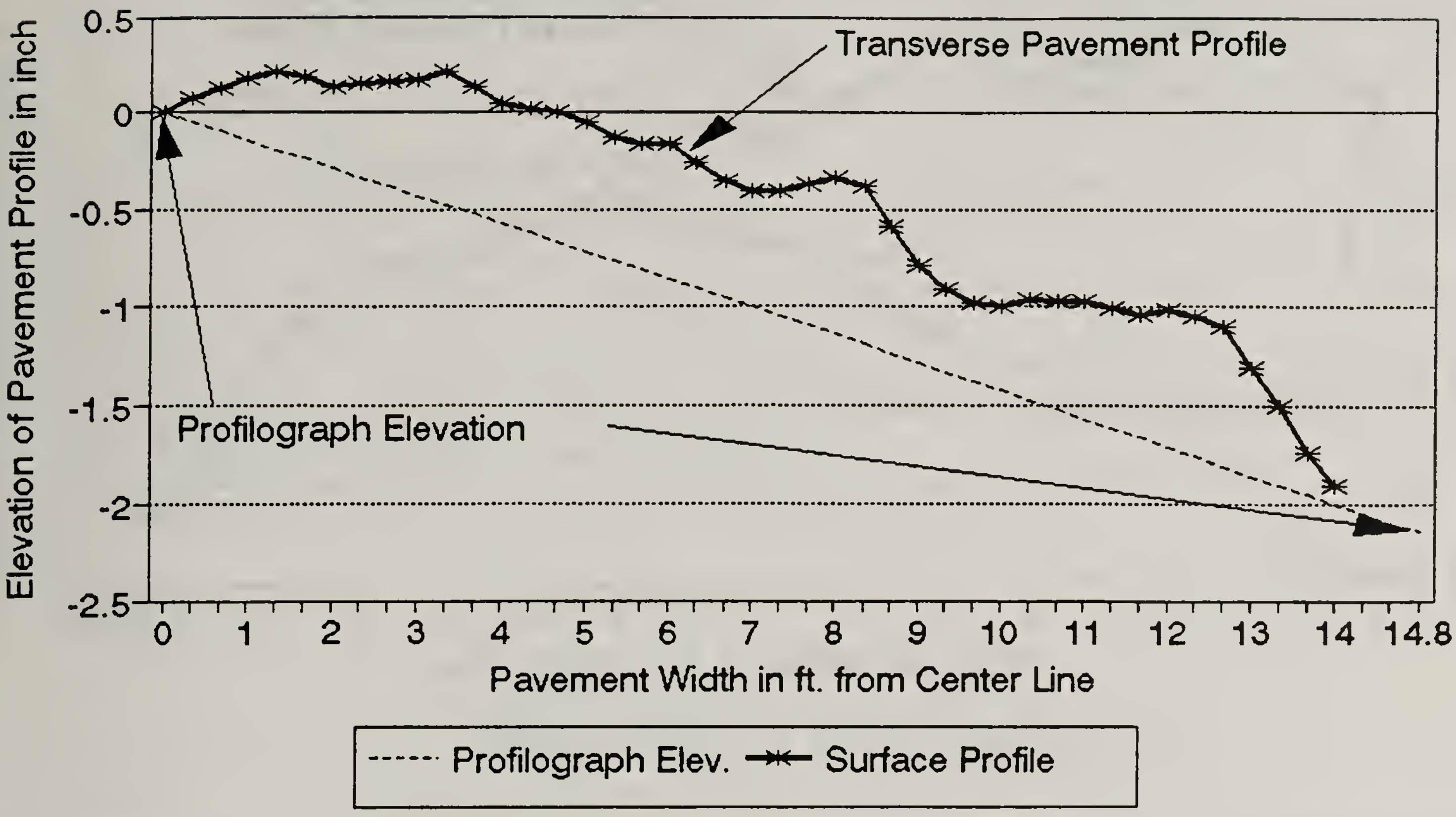
I-94 Pre-construction Pavement Profile
WBD Lane, Polybilt, 2226+00, MSU St. 7

Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section



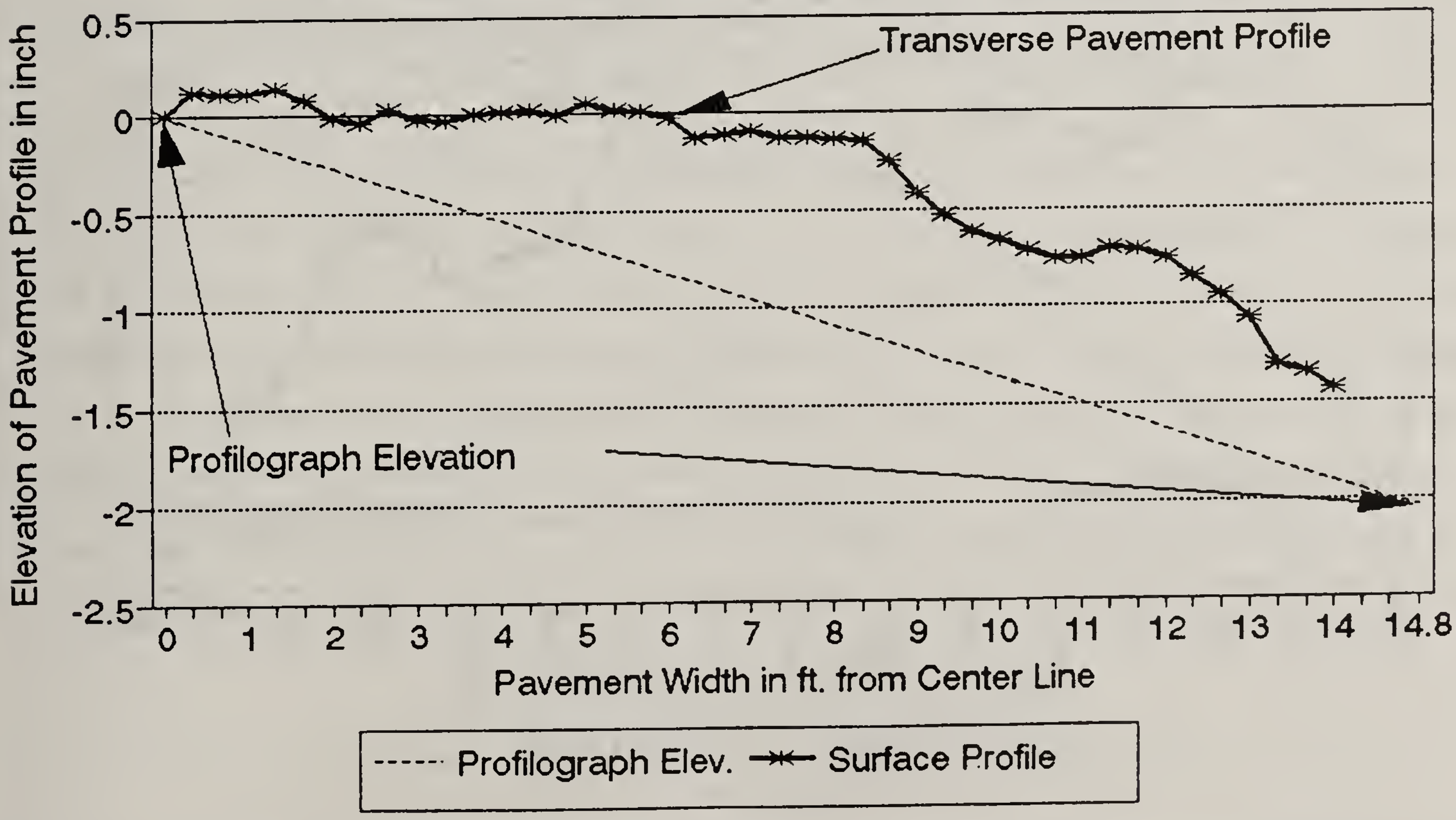
I-94 Pre-construction Pavement Profile
WBD Lane, Polybilt, 2220+00, MSU St. 8

Fig. 4A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



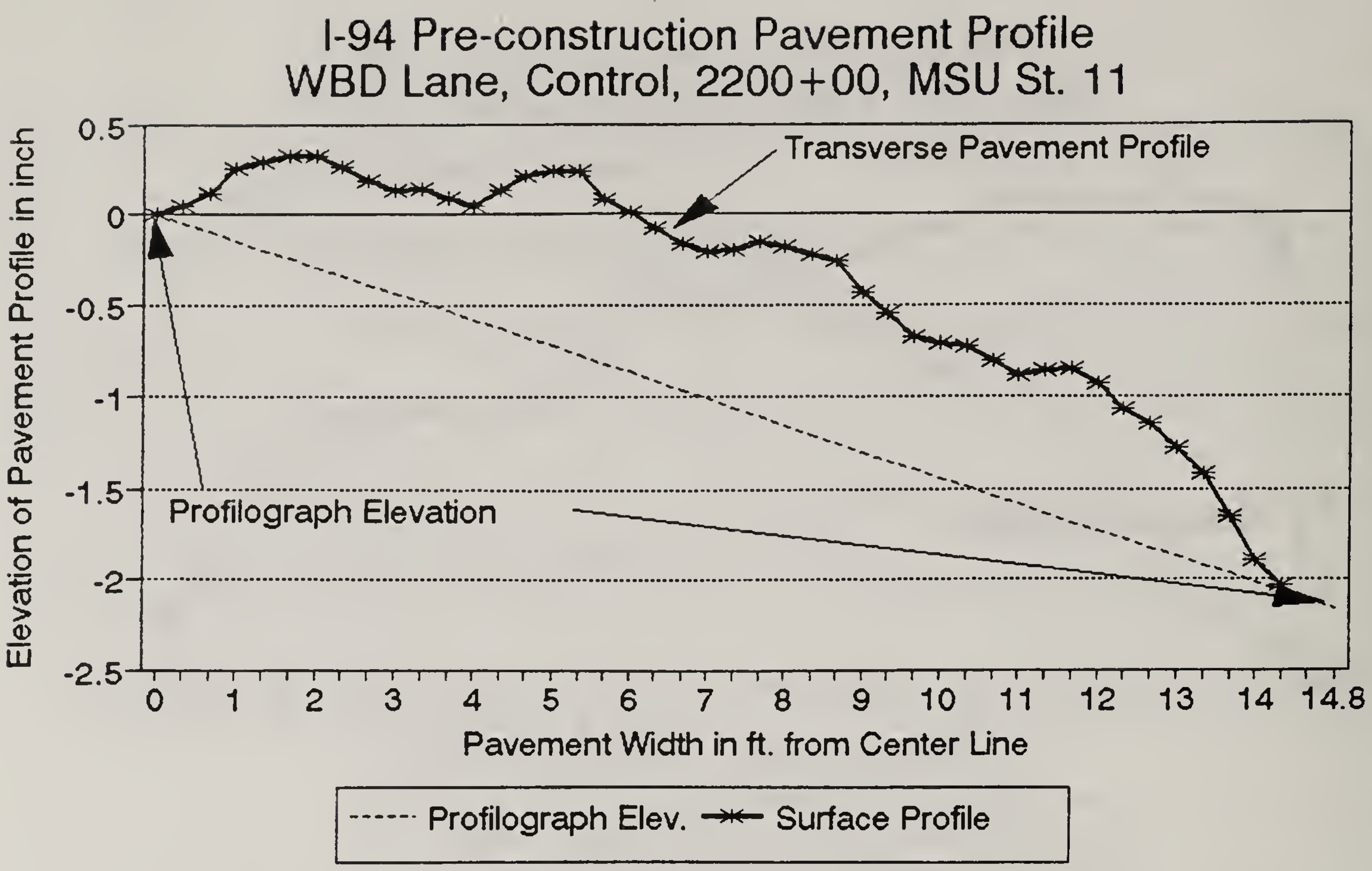
I-94 Pre-construction Pavement Profile
WBD Lane, Polybilt, 2214+00, MSU St. 9

Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section



I-94 Pre-construction Pavement Profile
WBD Lane, Polybilt, 2208+00, MSU St. 10

Fig. 5A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

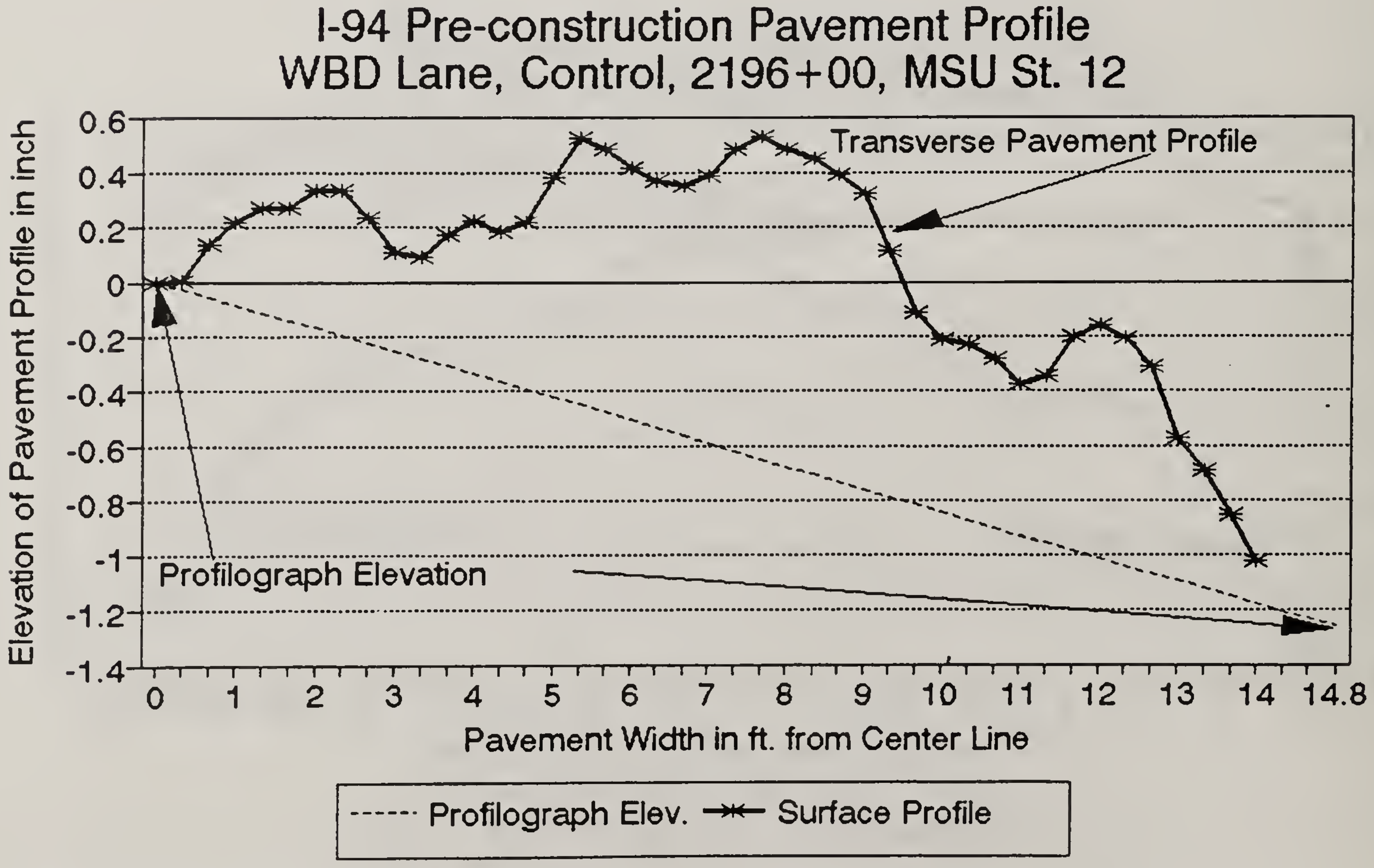
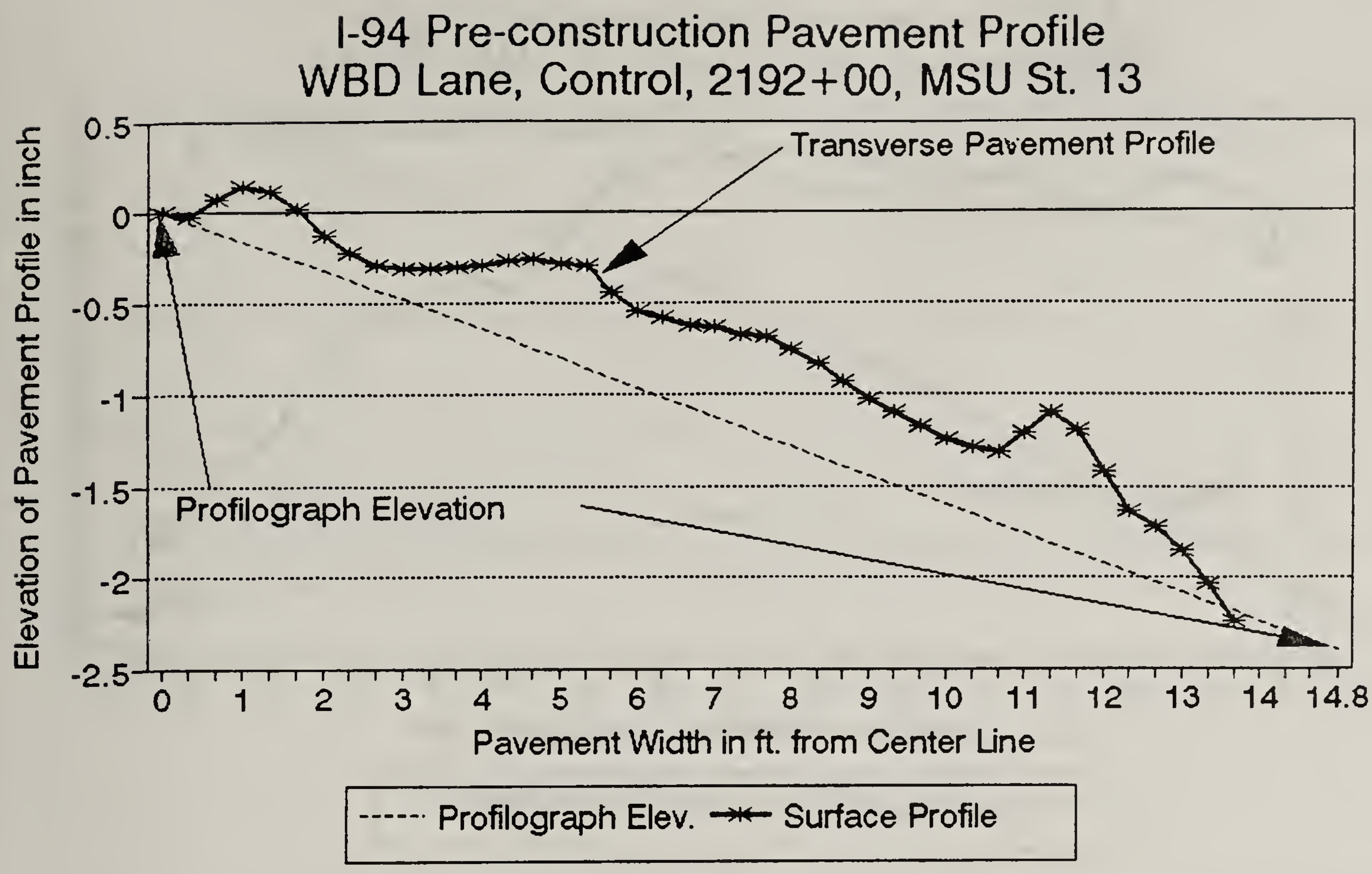


Fig. 6A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

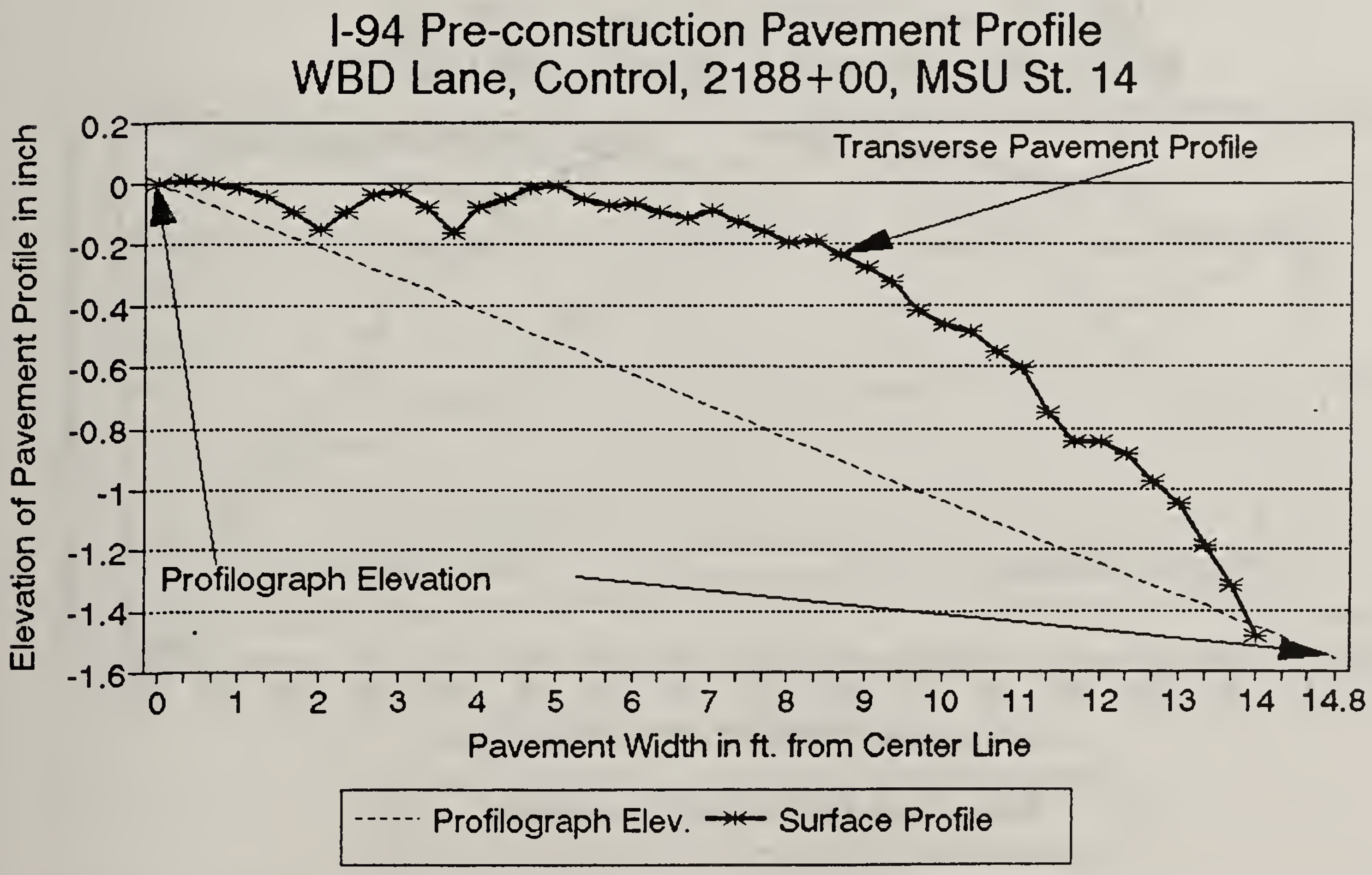
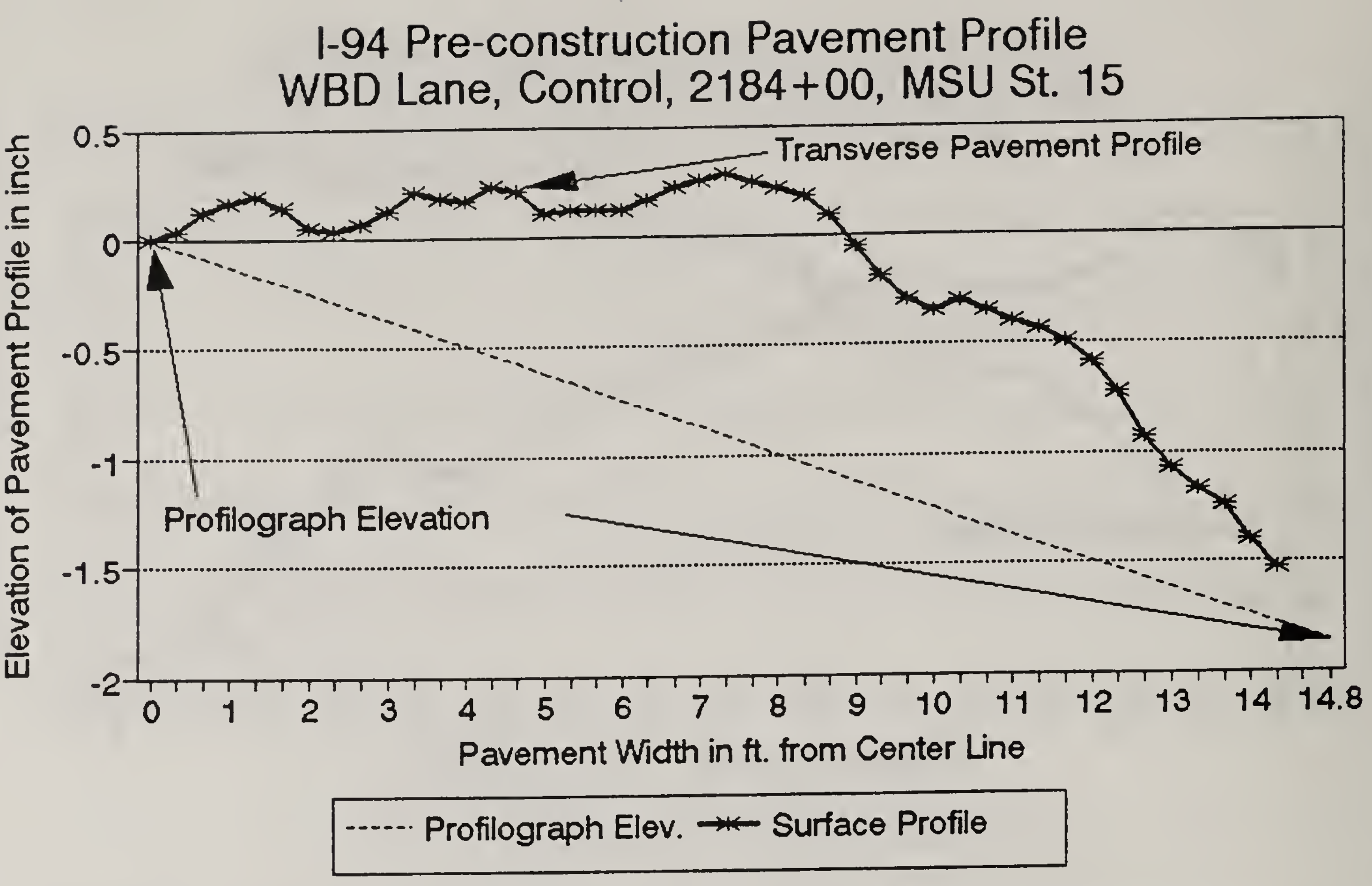


Fig. 7A. Pre-construction Profille and Elevation, Center Line of Pavement as Origin


I-94 Pre-construction Pavement Profile
WBD Lane, Control, 2184+00, MSU St. 15

Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

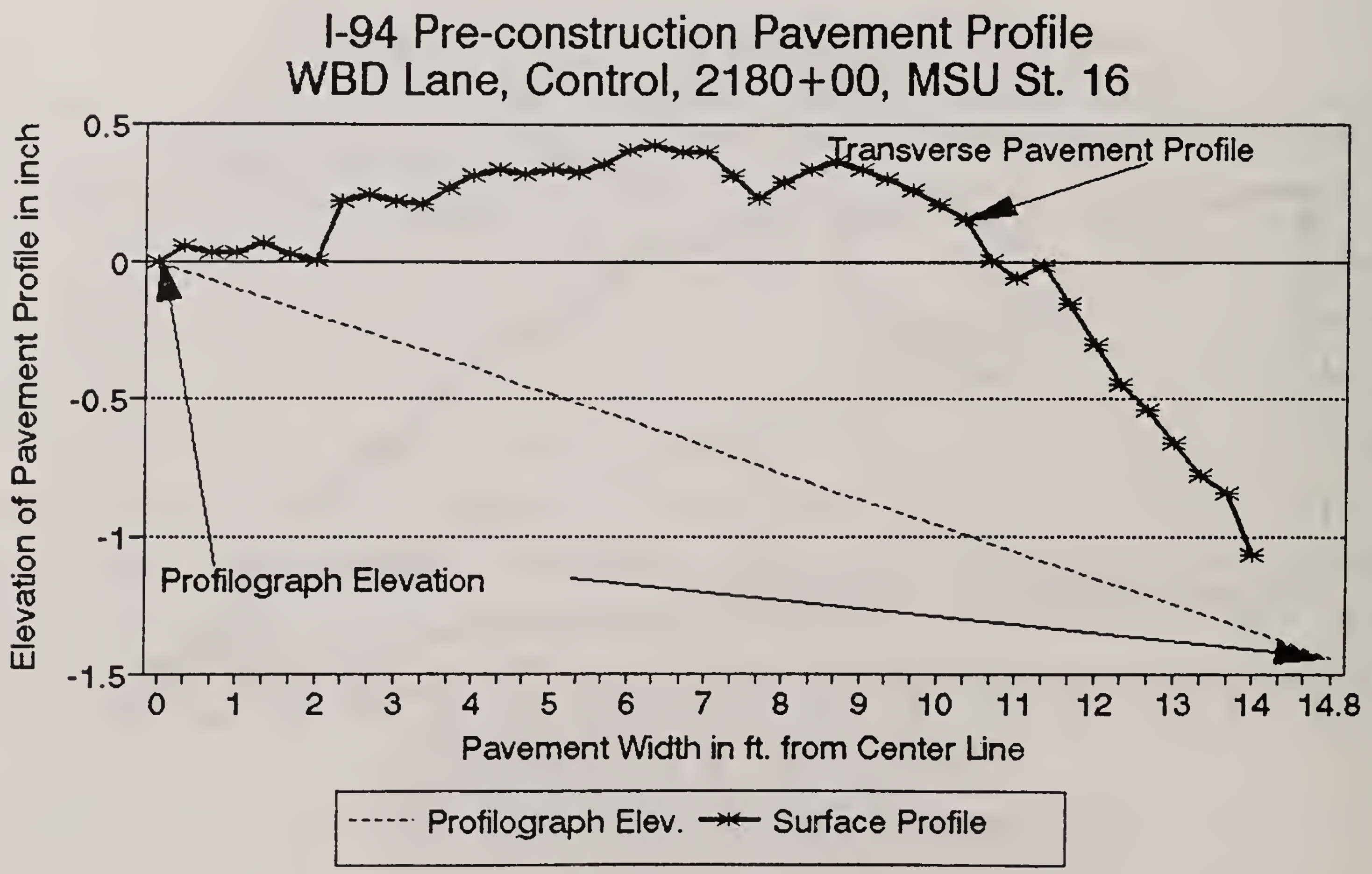
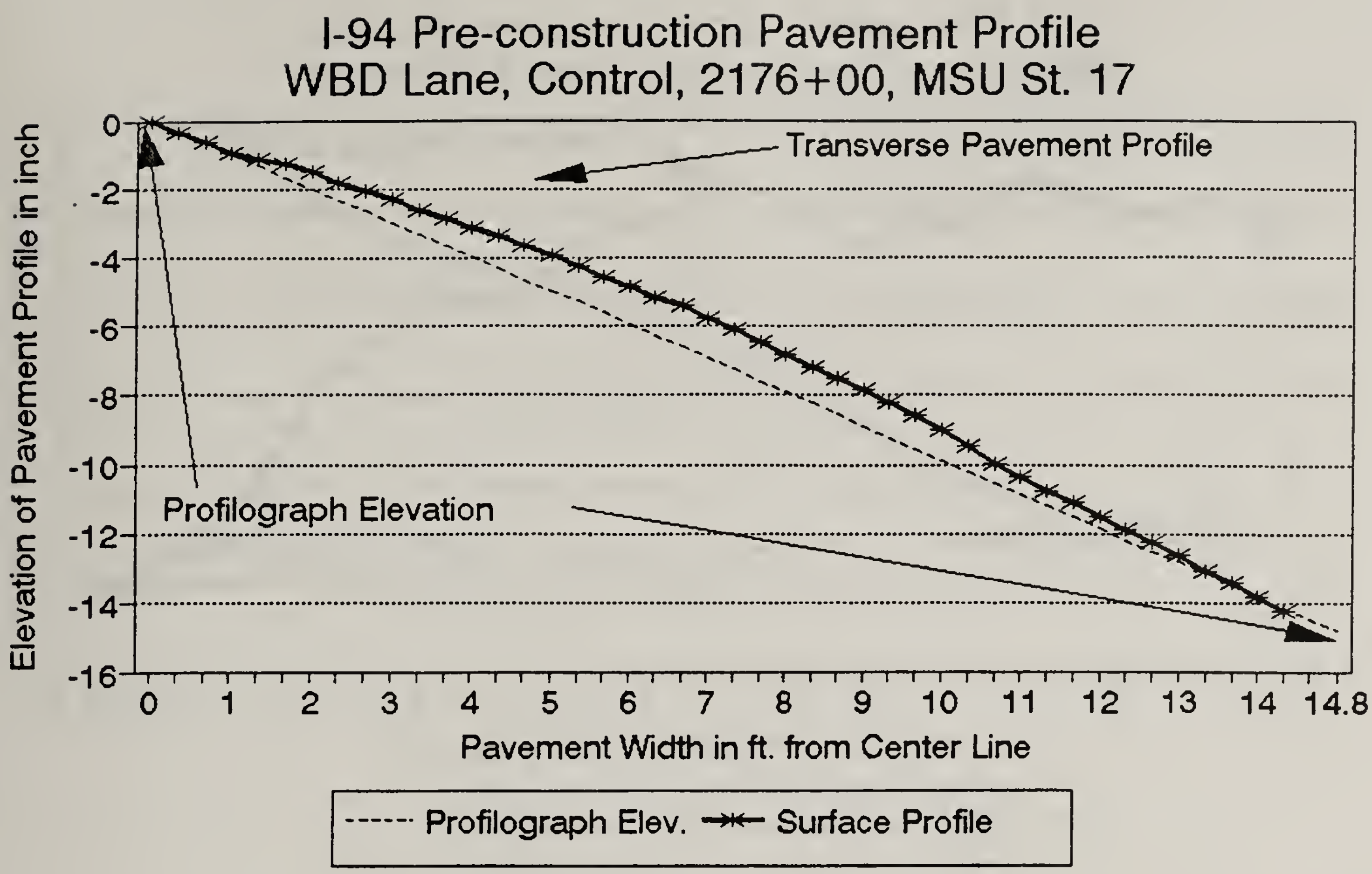

I-94 Pre-construction Pavement Profile
WBD Lane, Control, 2180+00, MSU St. 16

Fig. 8A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

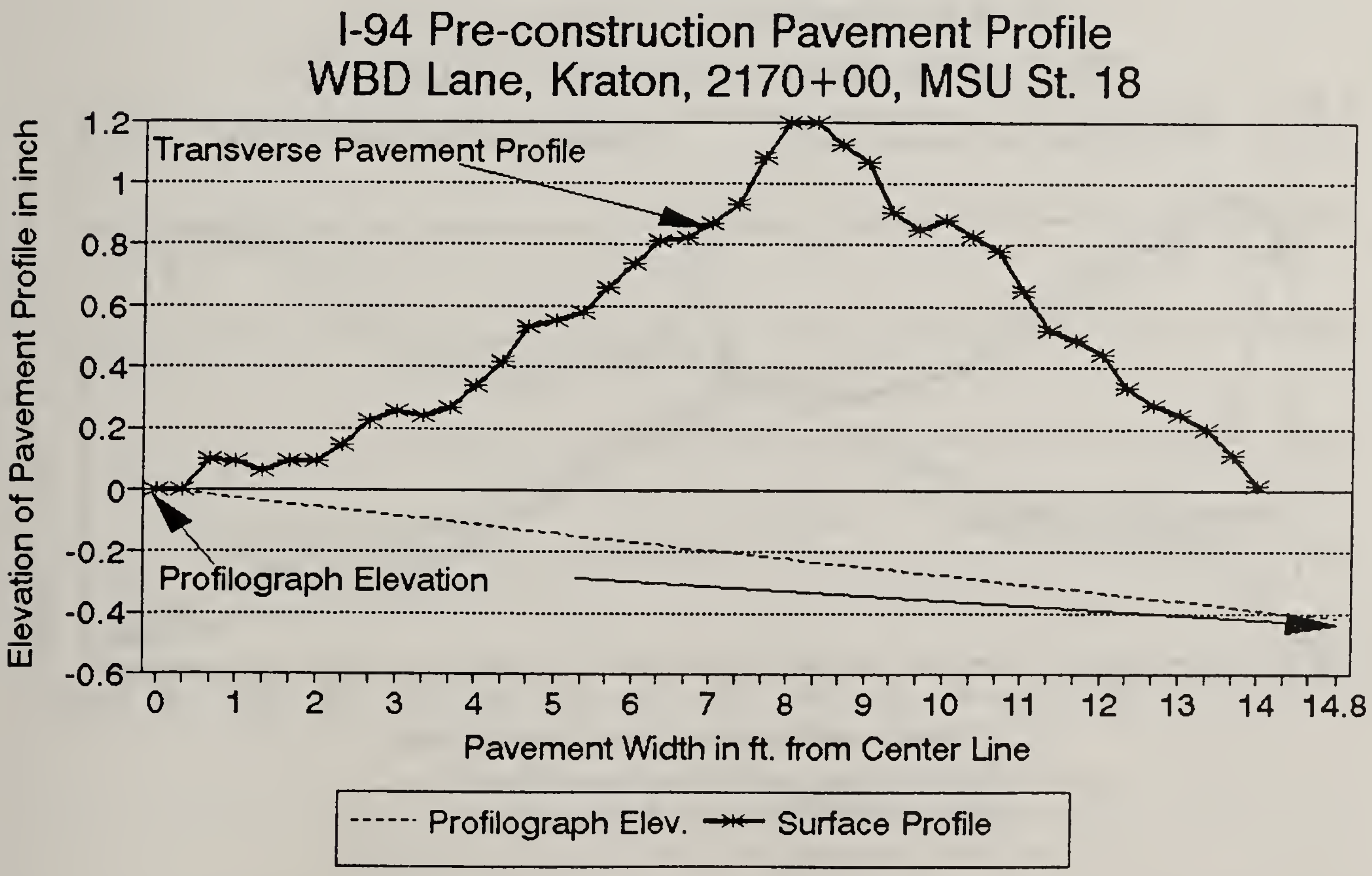
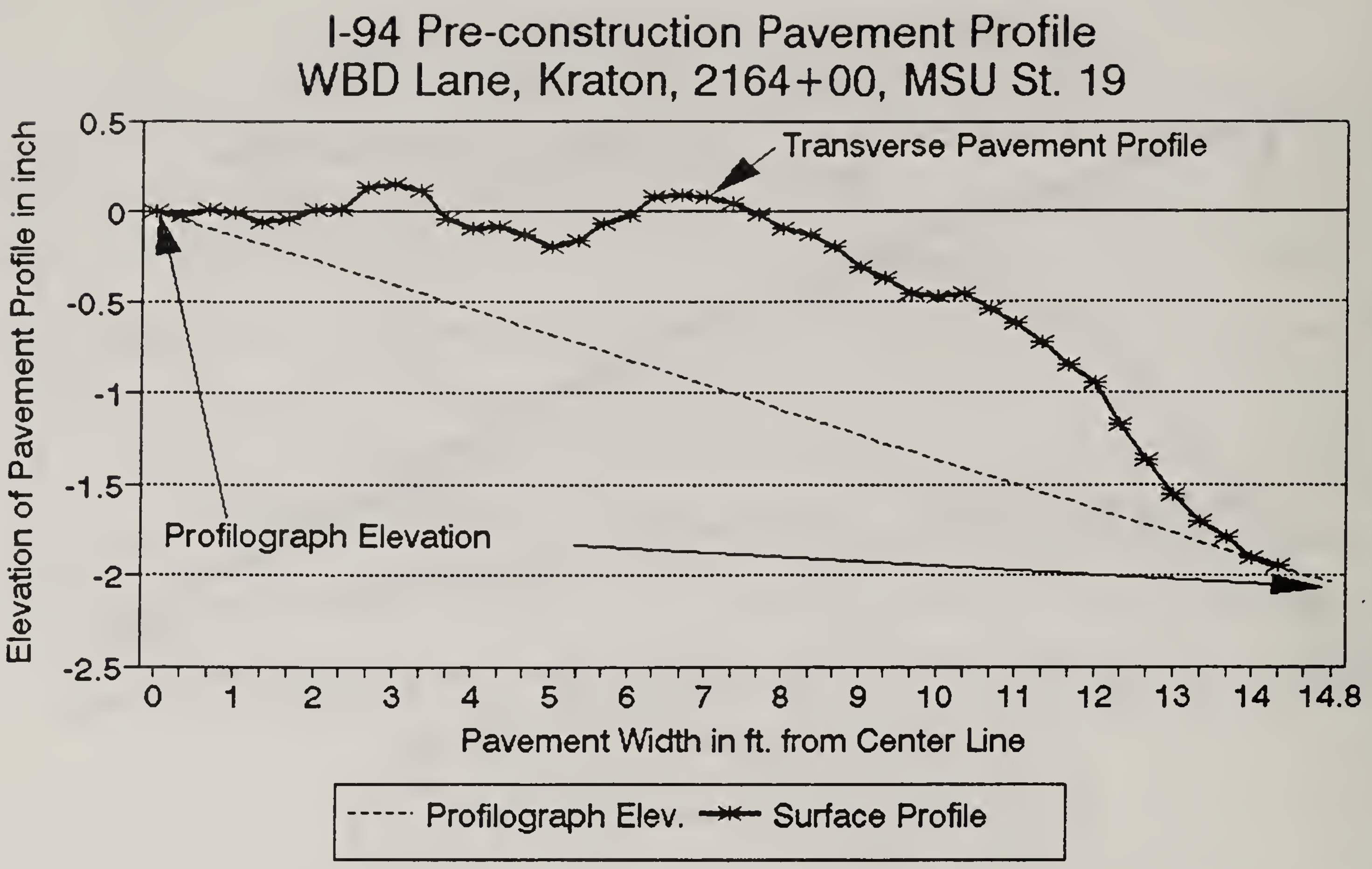


Fig. 9A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Pre-construction Pavement Profile
WBD Lane, Kraton, 2164+00, MSU St. 19

Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

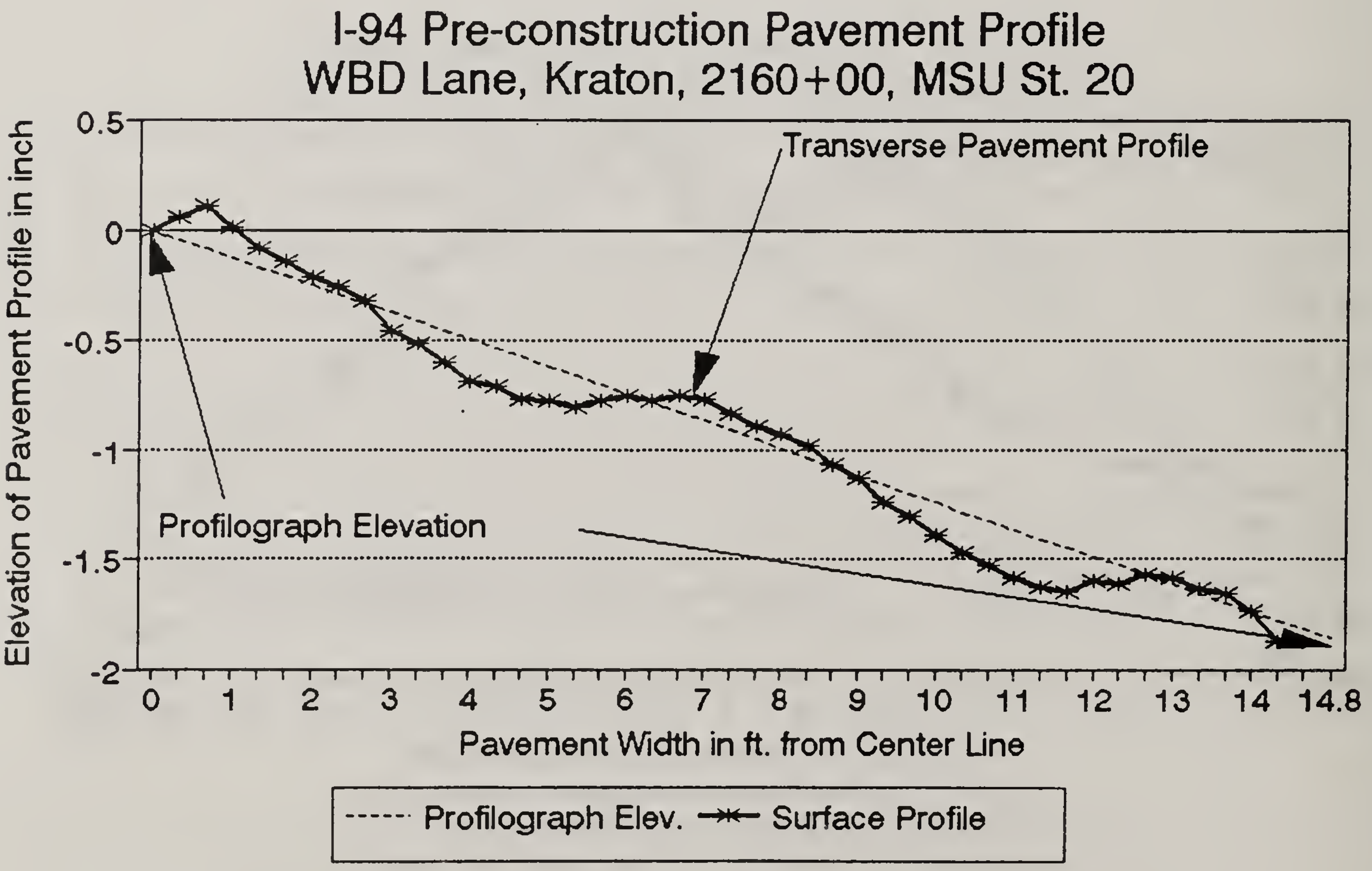
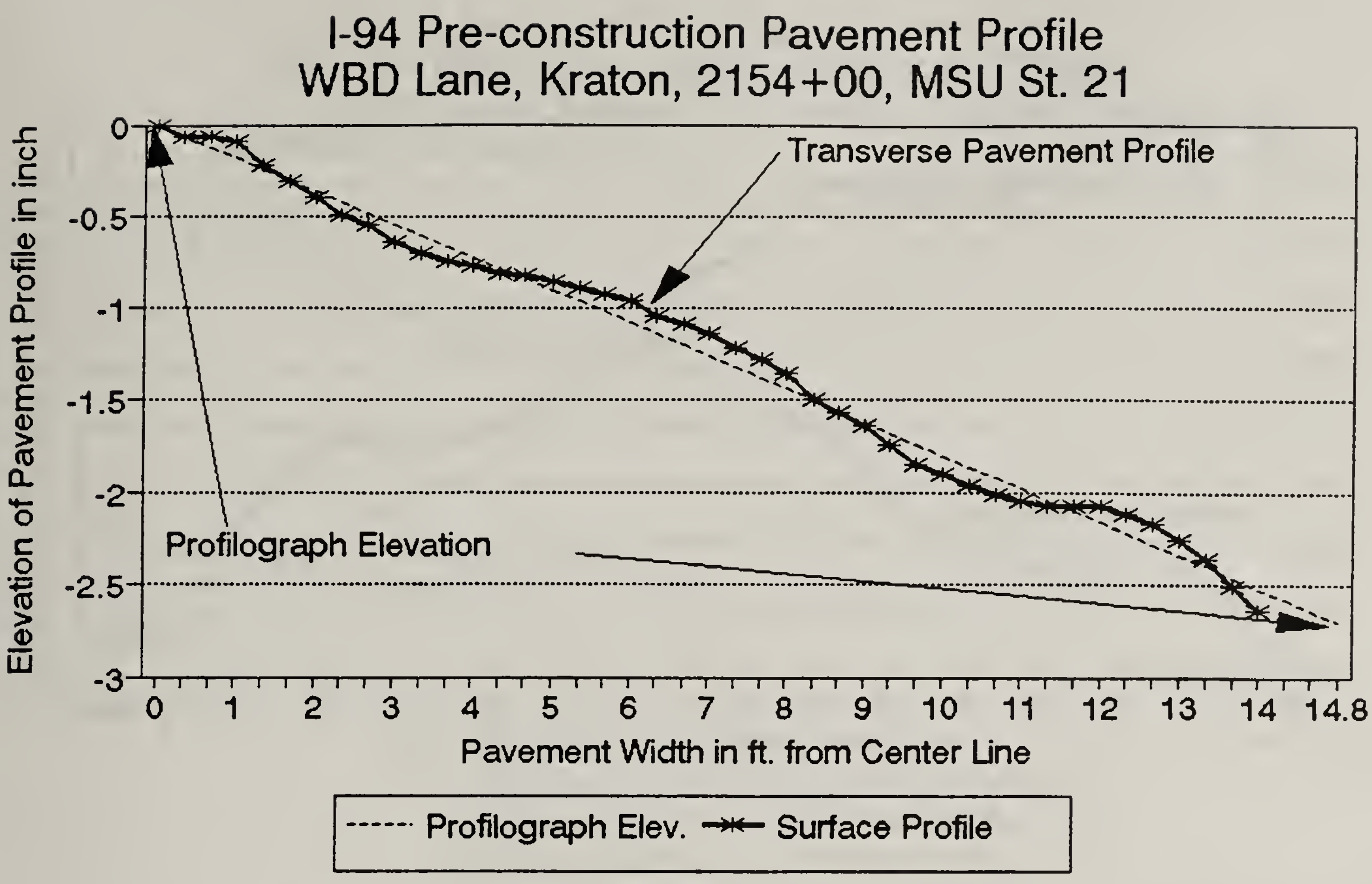

I-94 Pre-construction Pavement Profile
WBD Lane, Kraton, 2160+00, MSU St. 20

Fig. 10A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Pre-construction Pavement Profile
WBD Lane, Kraton, 2154+00, MSU St. 21

Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

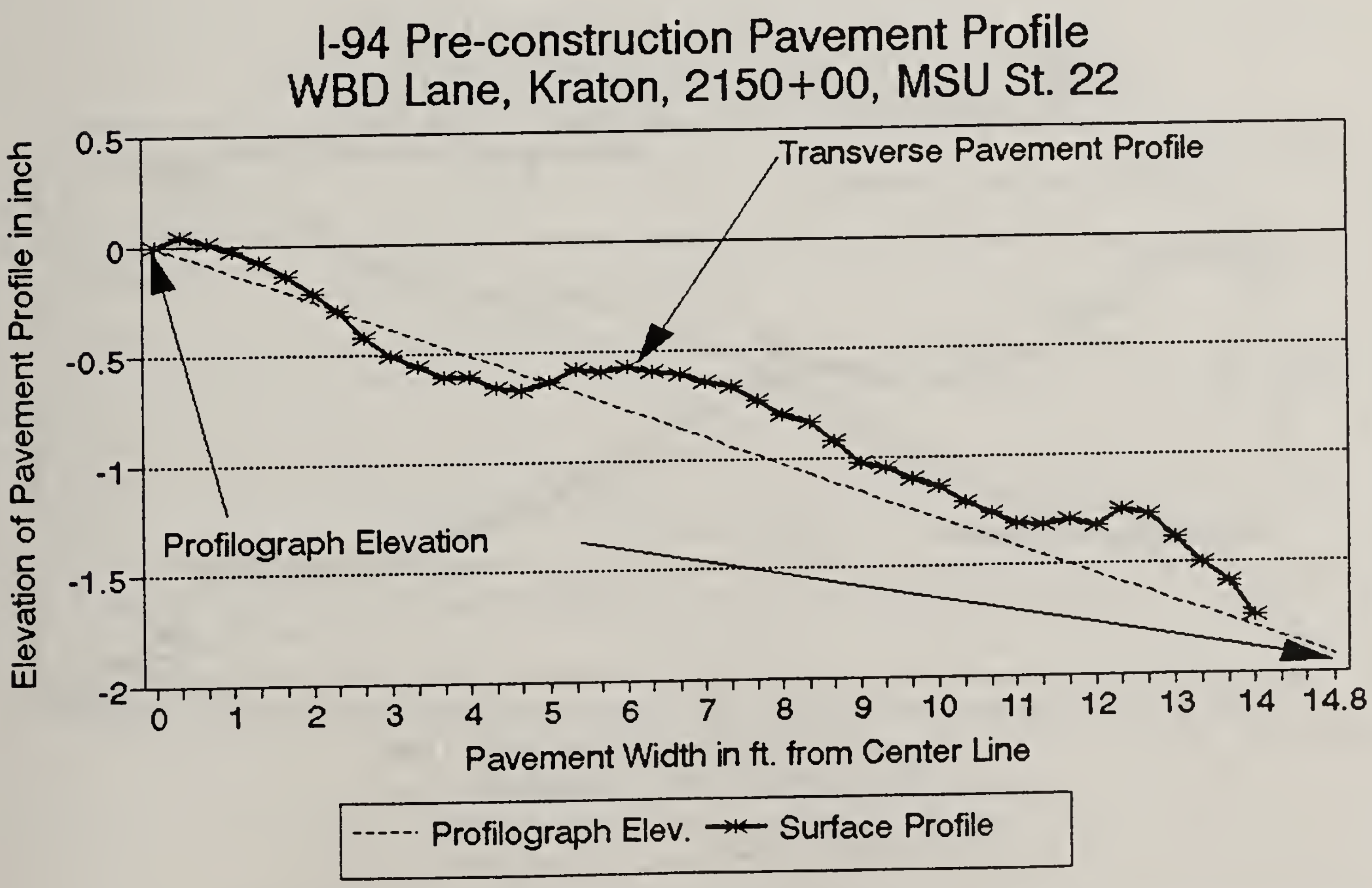
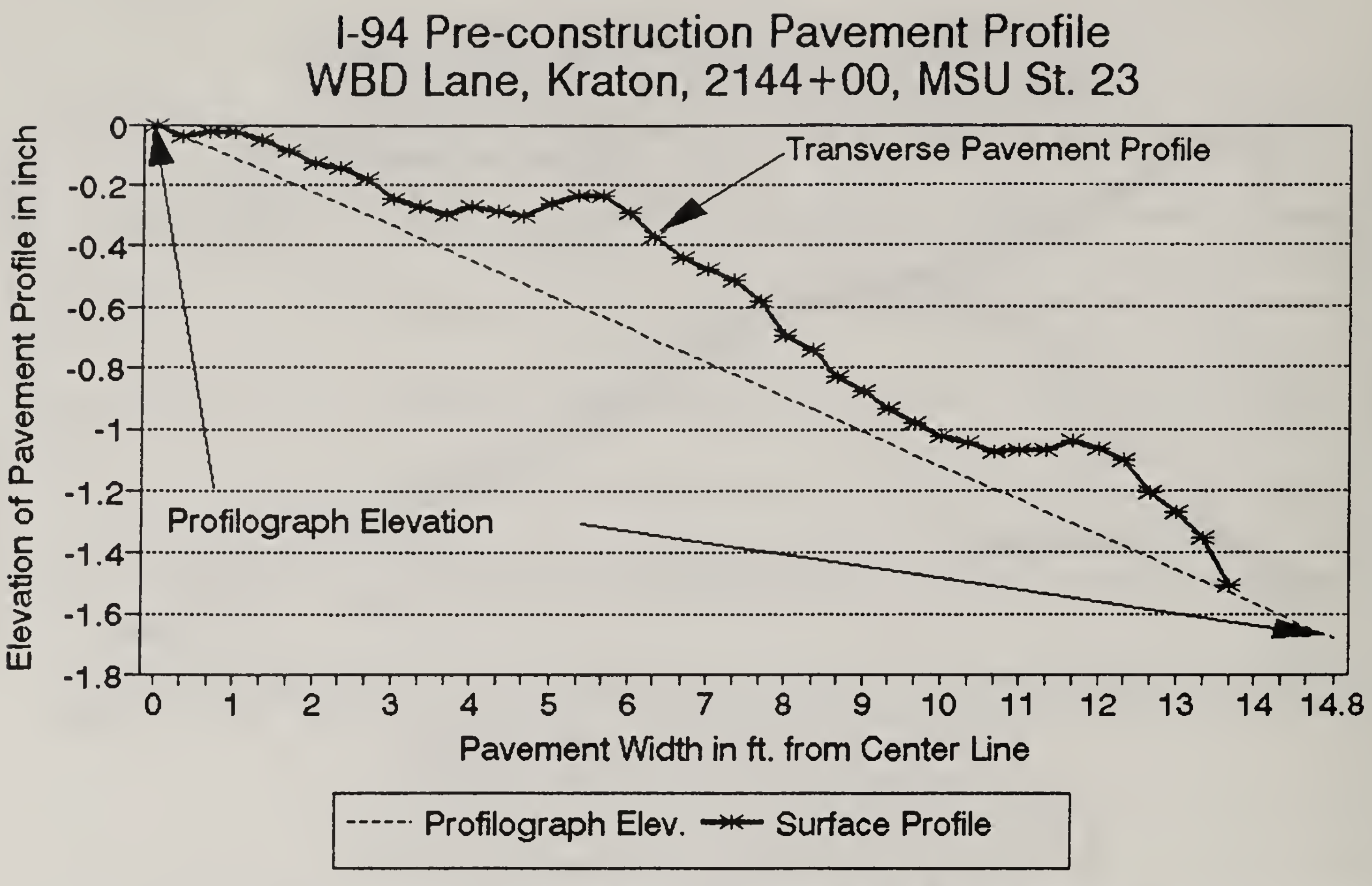

I-94 Pre-construction Pavement Profile
WBD Lane, Kraton, 2150+00, MSU St. 22

Fig. 11A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

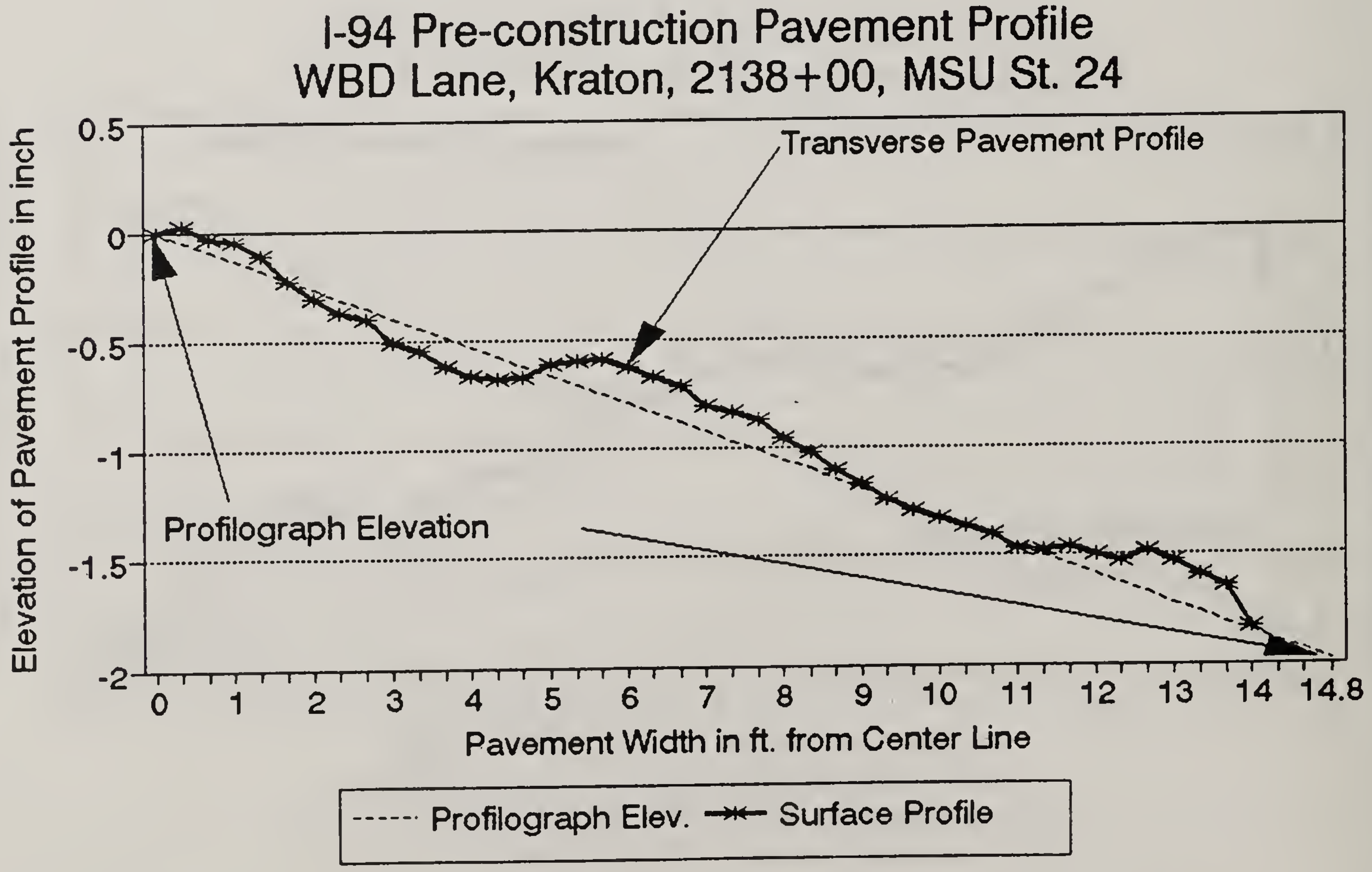
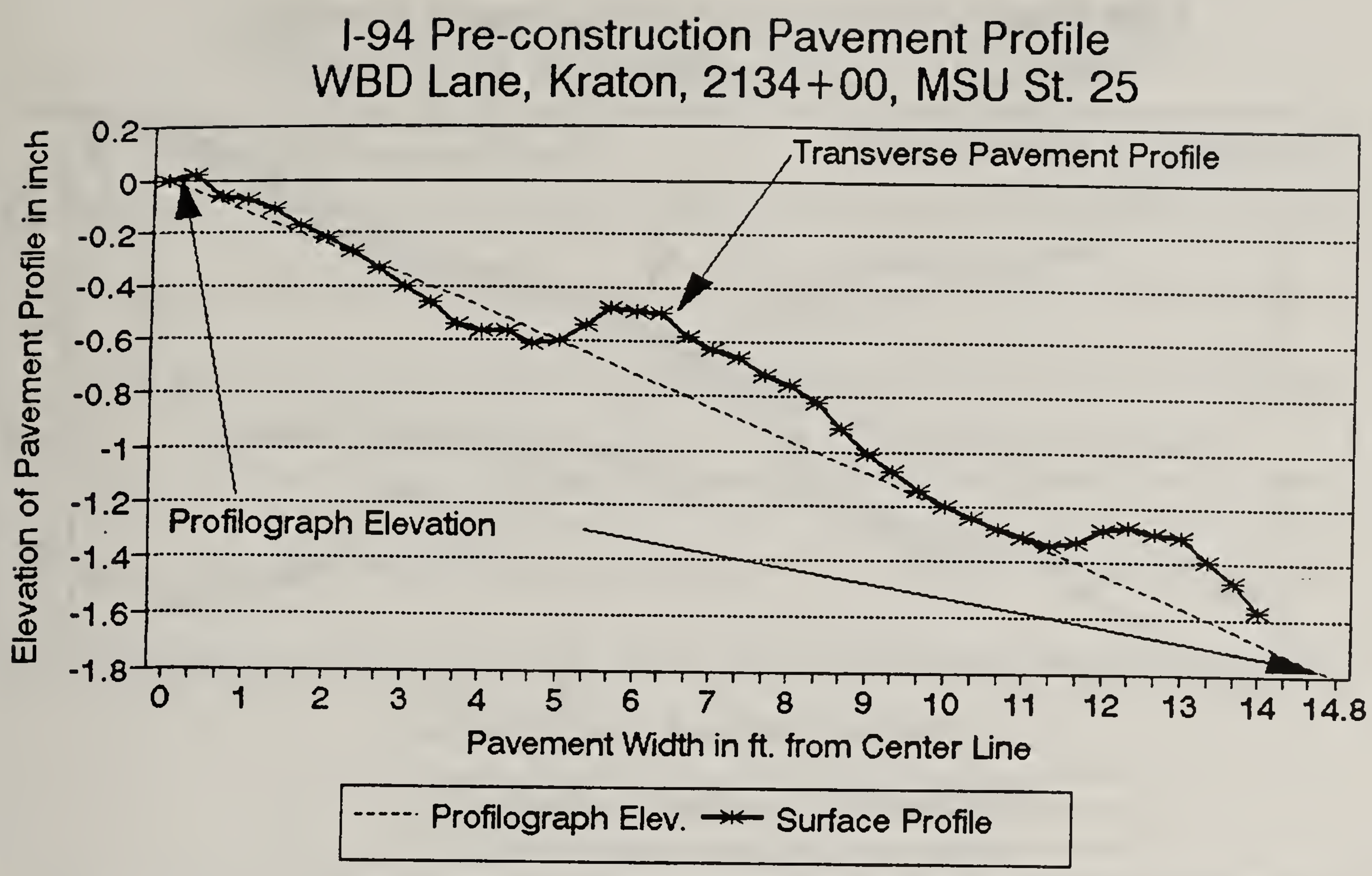


Fig. 12A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

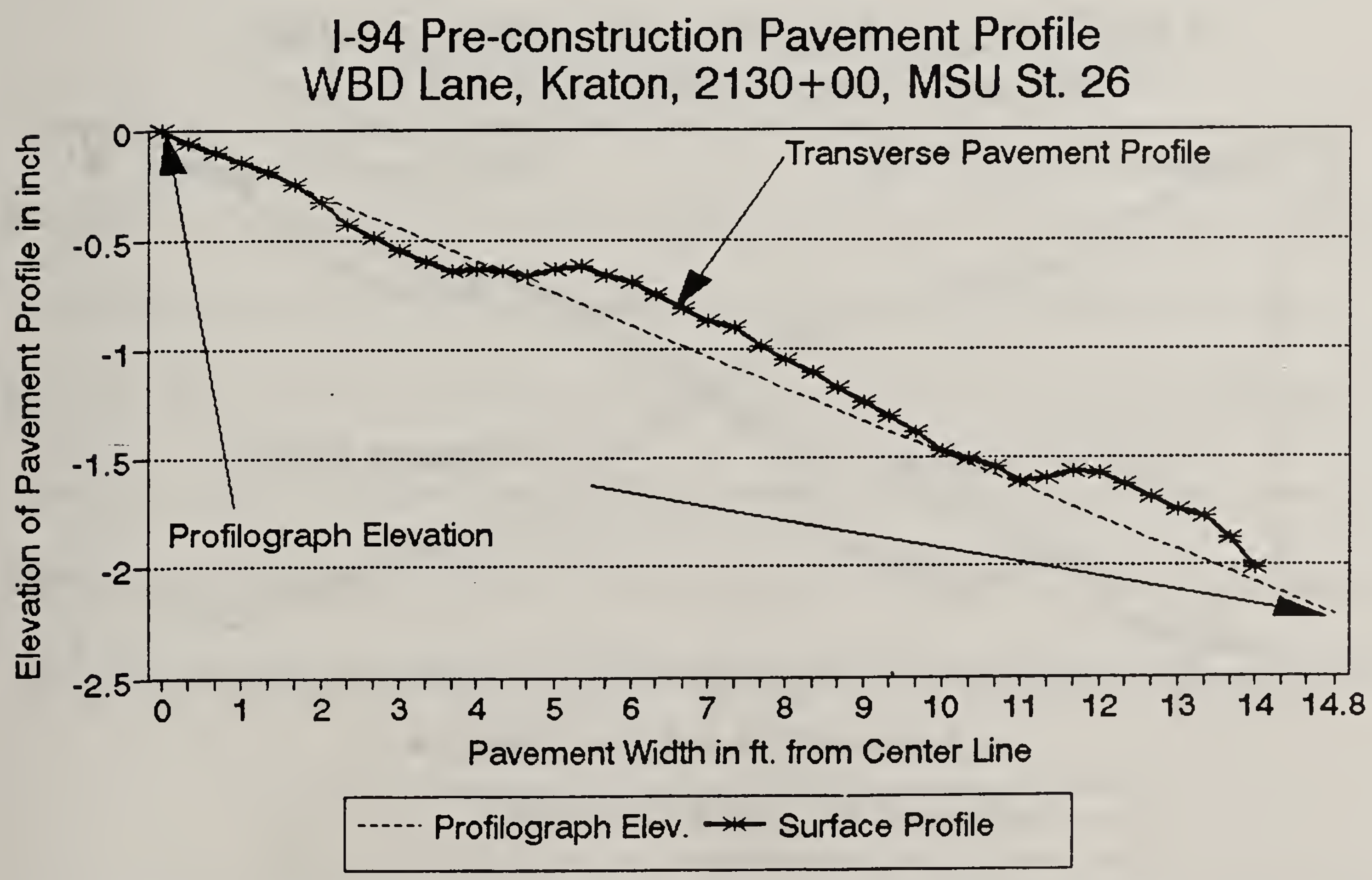
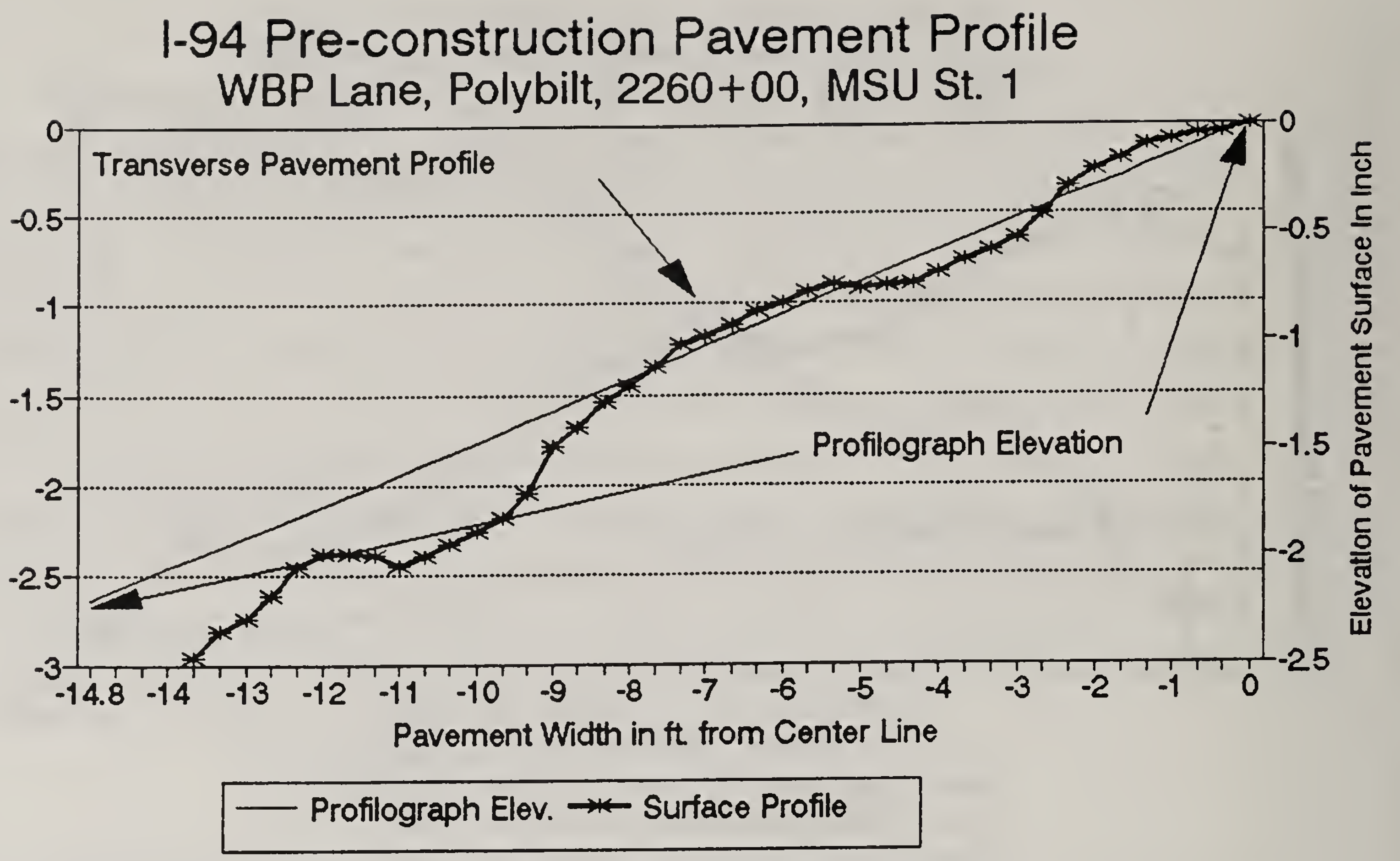


Fig.13A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section

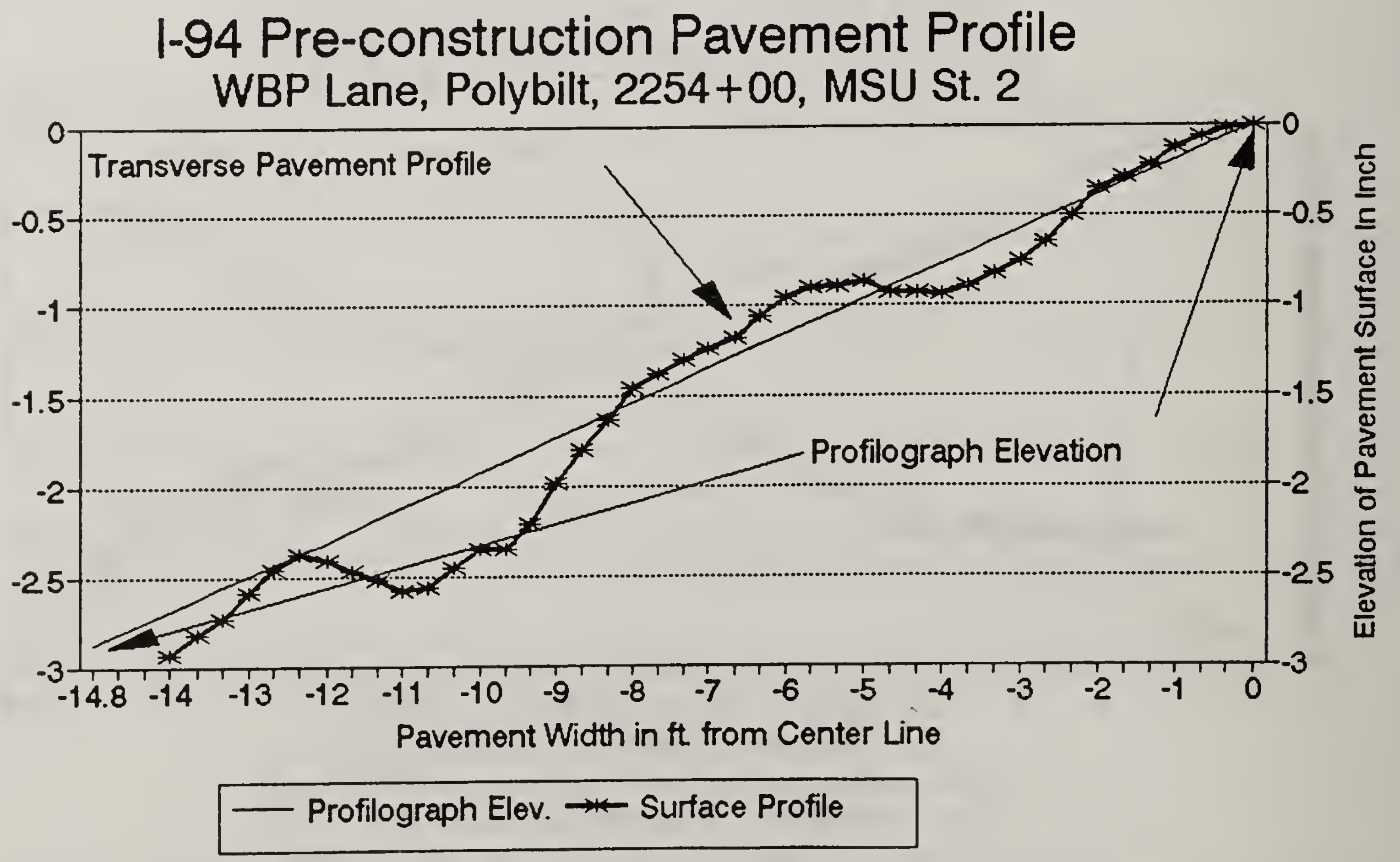
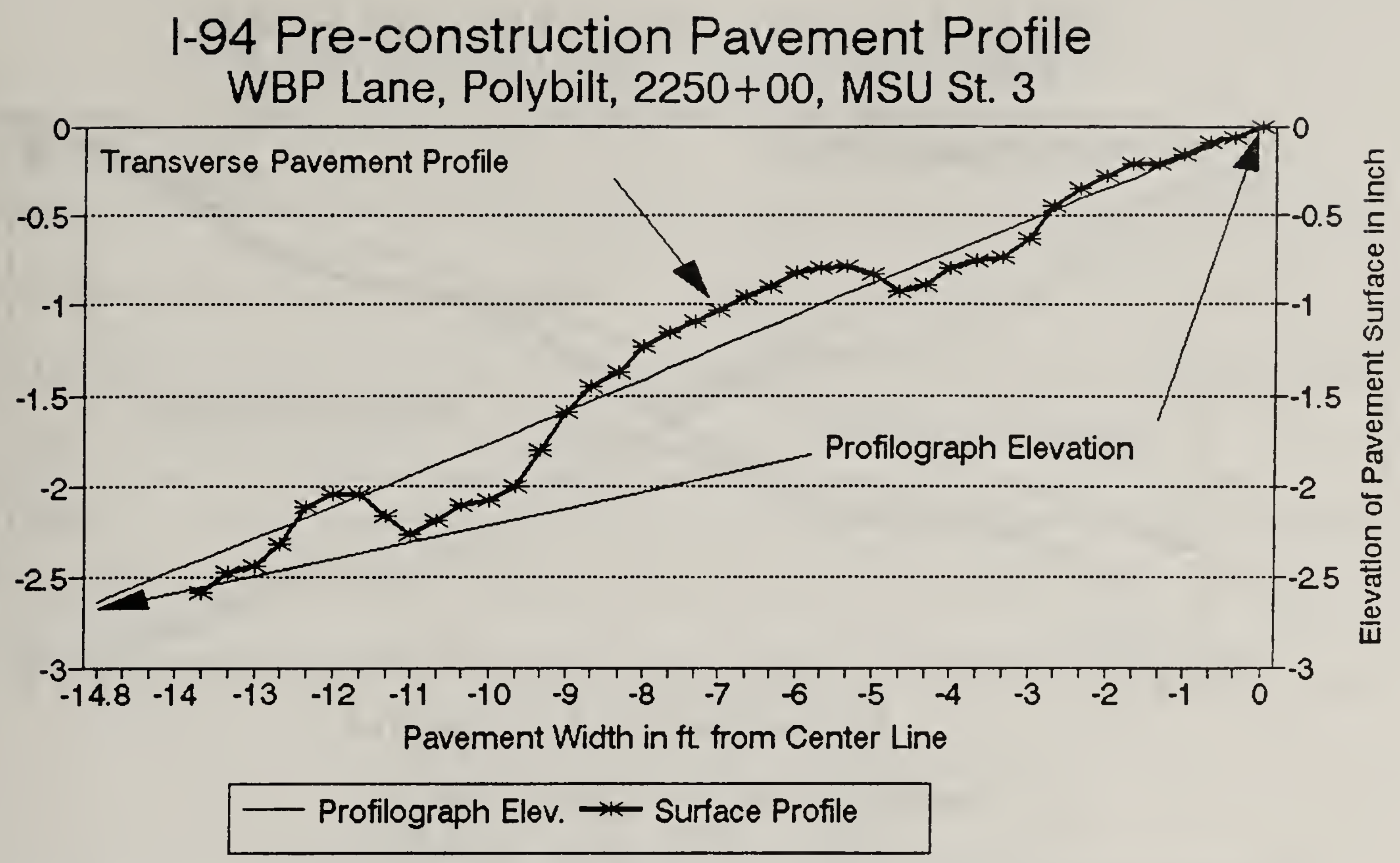


Figure 1B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Pre-construction Pavement Profile
WBP Lane, Polybilt, 2250+00, MSU St. 3

Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section

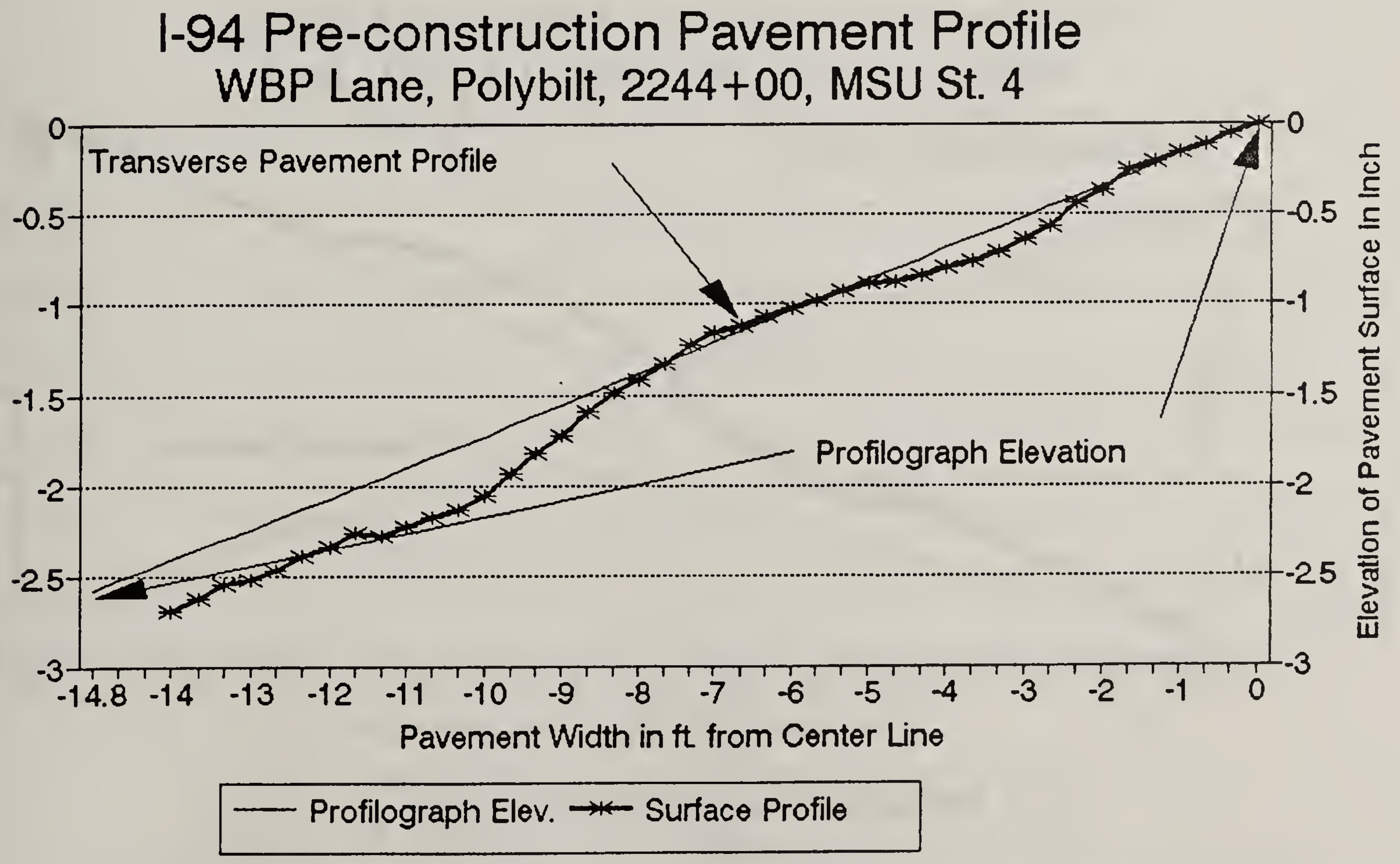
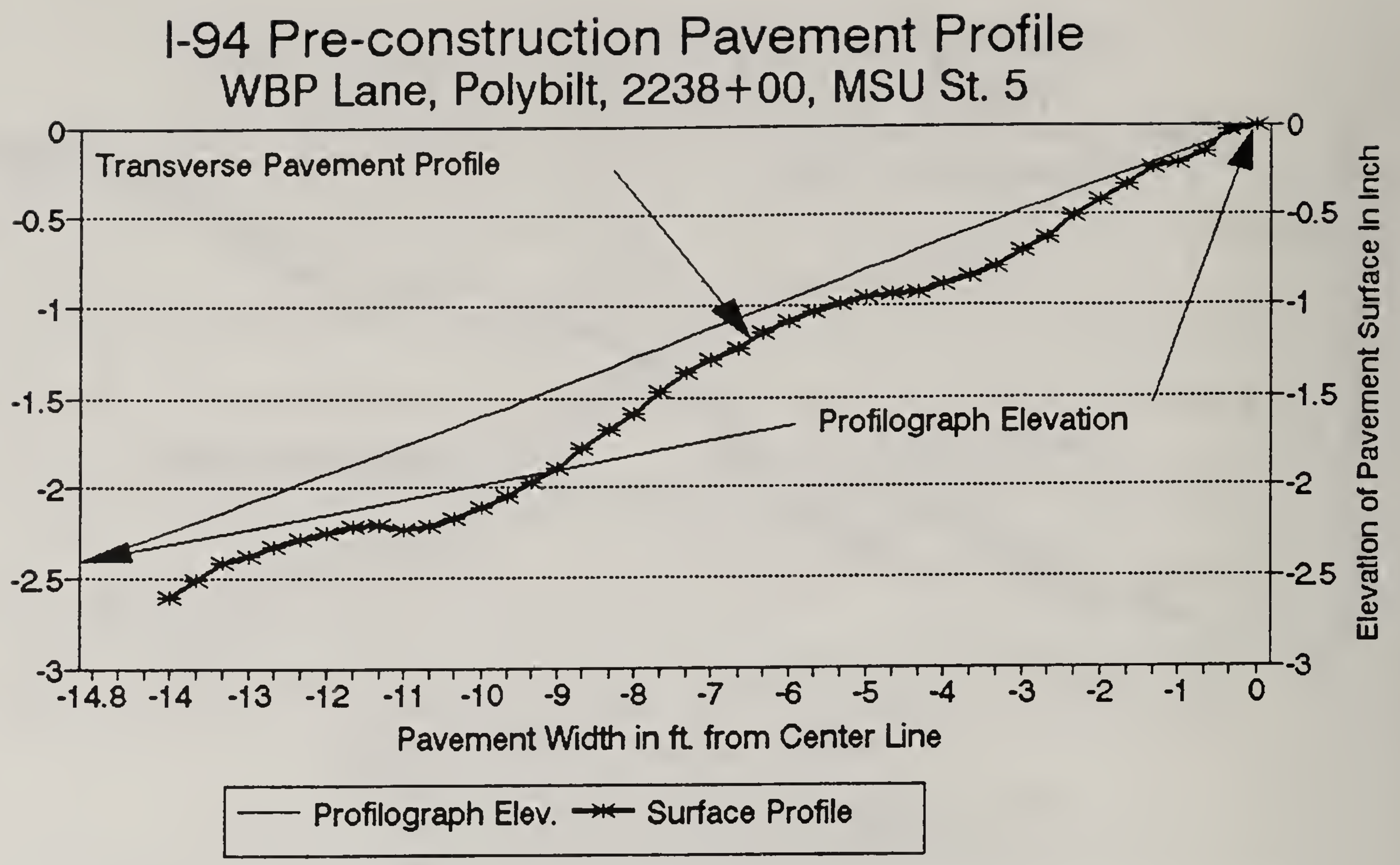

I-94 Pre-construction Pavement Profile
WBP Lane, Polybilt, 2244+00, MSU St. 4

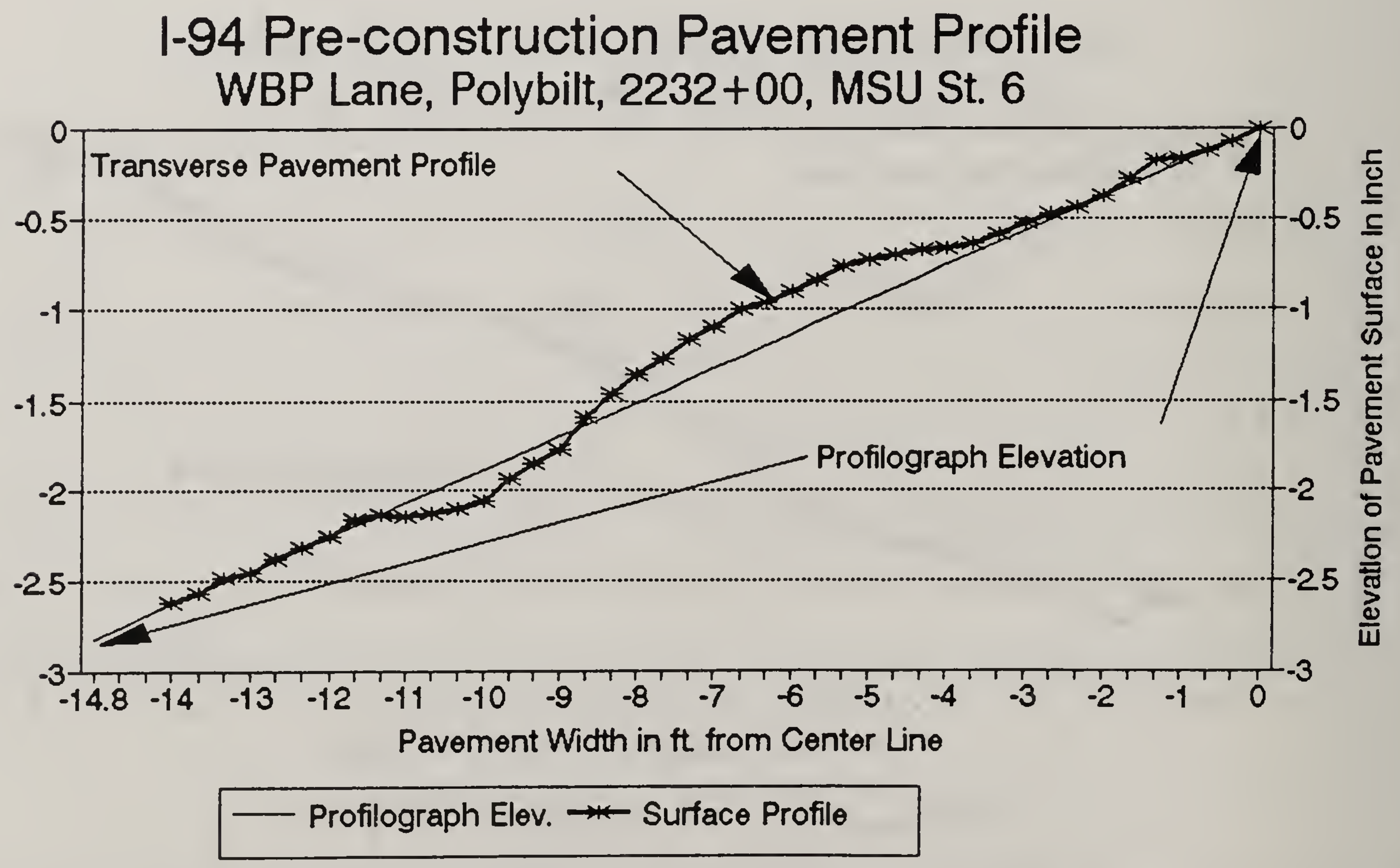
Figure 2B. Pre-conatruction Profile and Elevation, Center Line of Pavement as Origin



I-94 Pre-construction Pavement Profile

WBP Lane, Polybilt, 2238+00, MSU St. 5

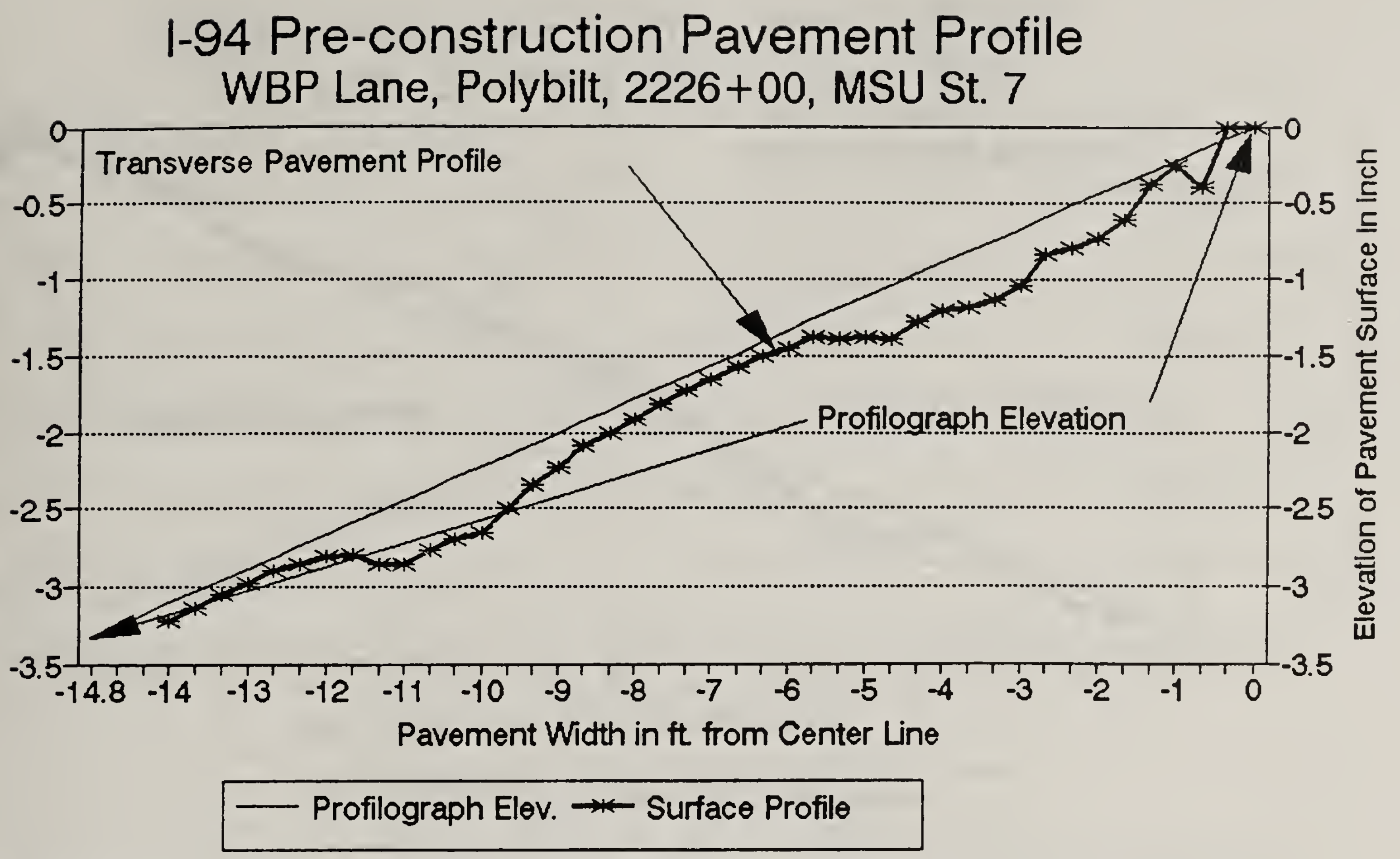
Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section



I-94 Pre-construction Pavement Profile

WBP Lane, Polybilt, 2232+00, MSU St. 6

Figure 3B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section

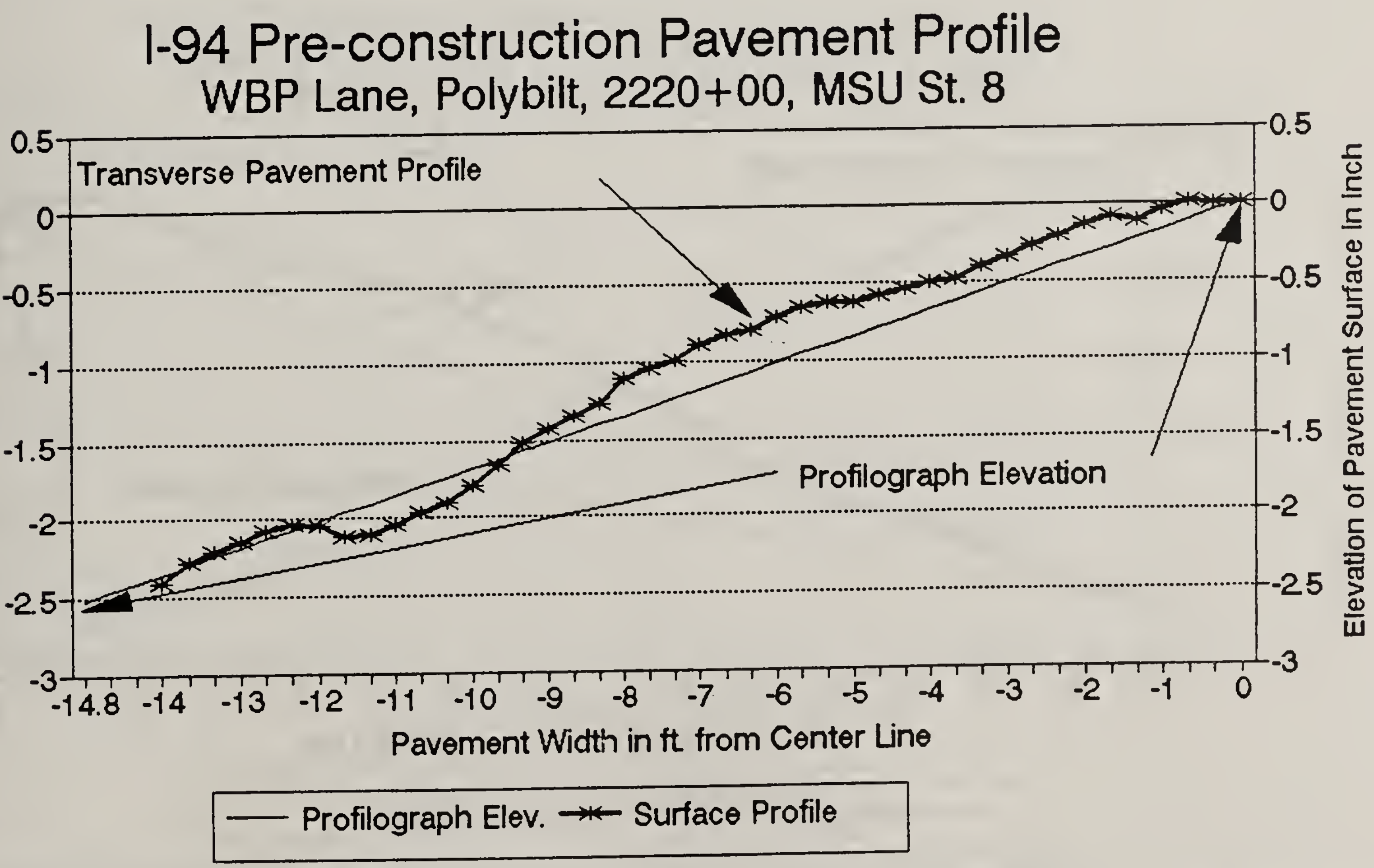
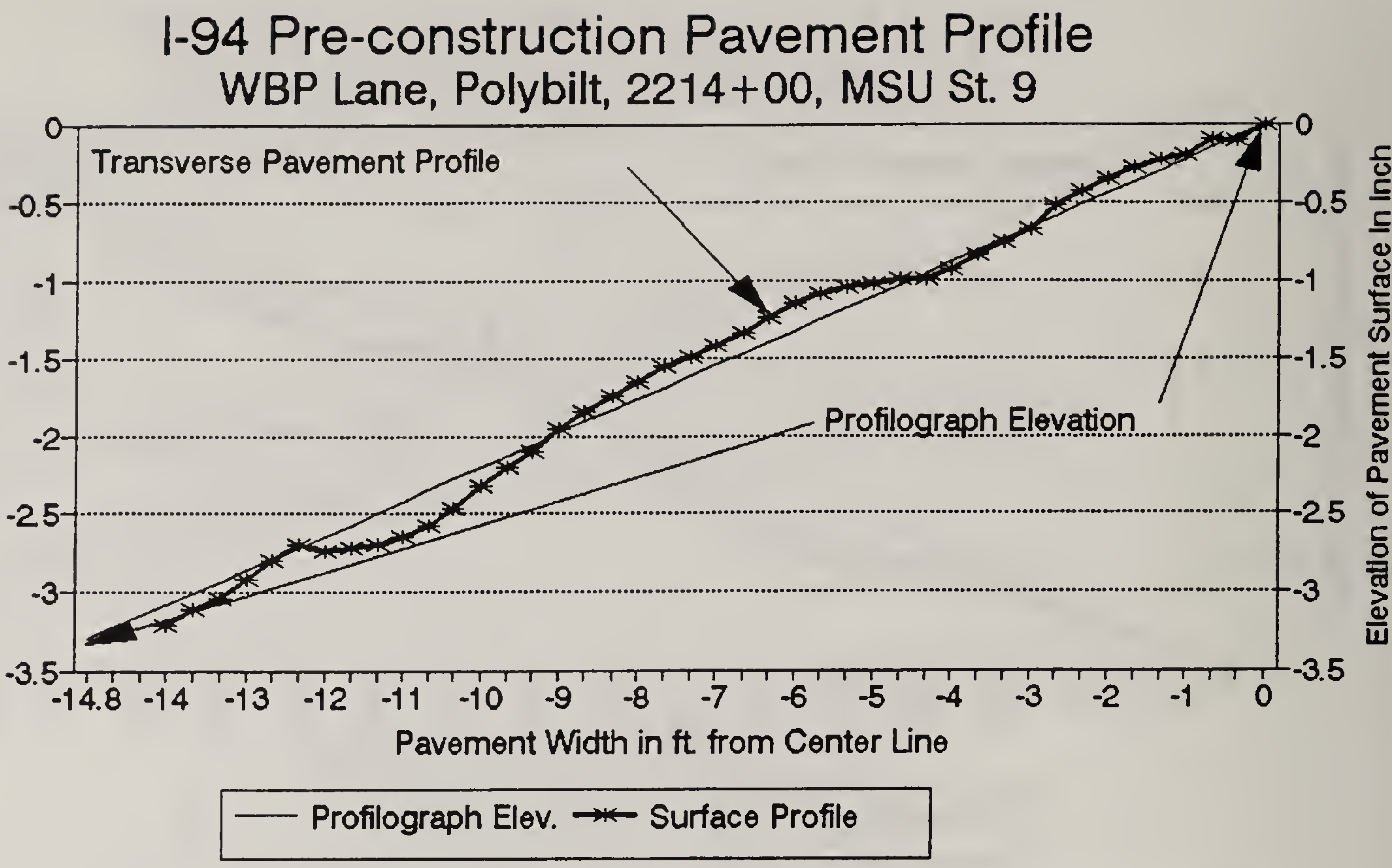


Figure 4B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section

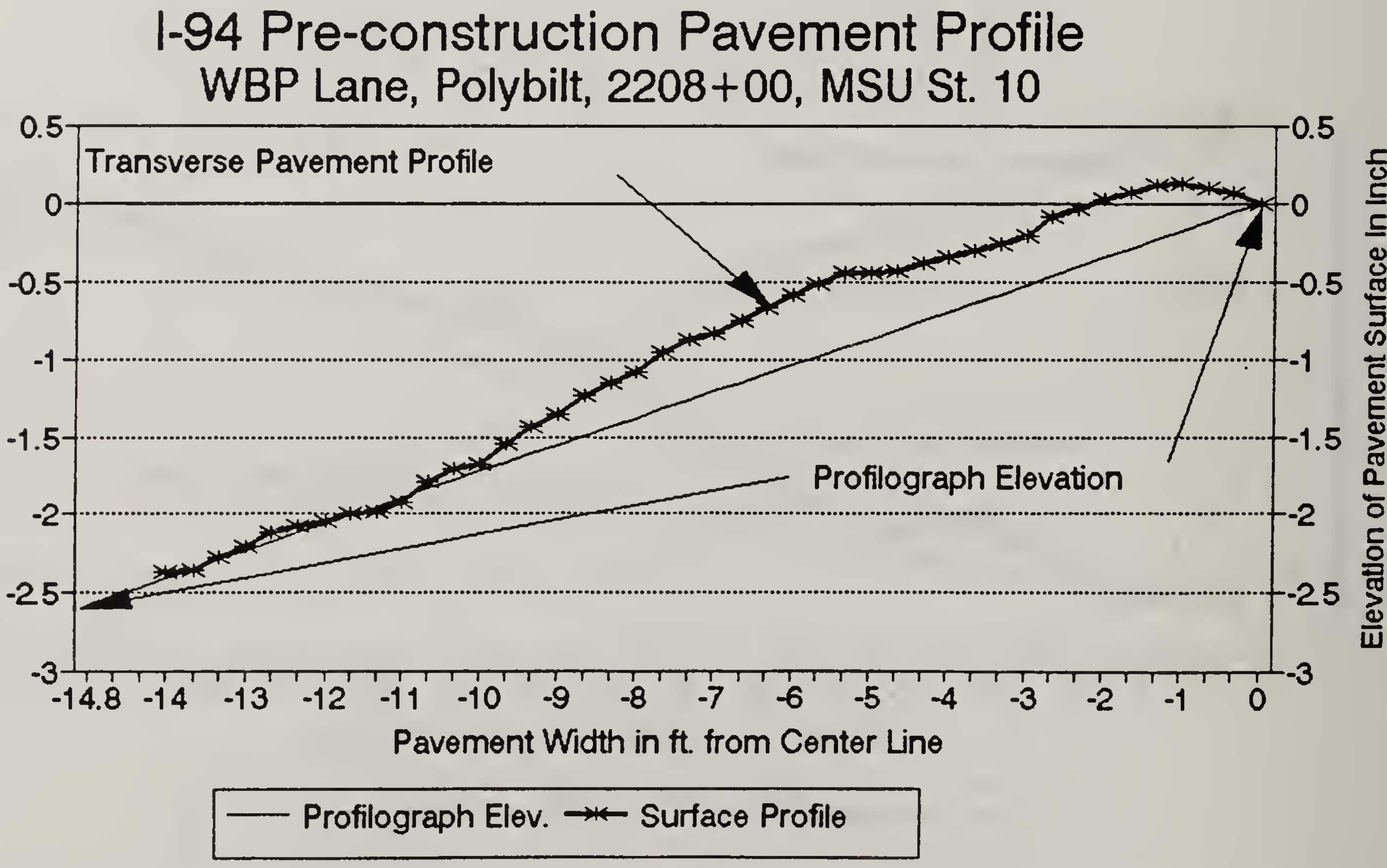
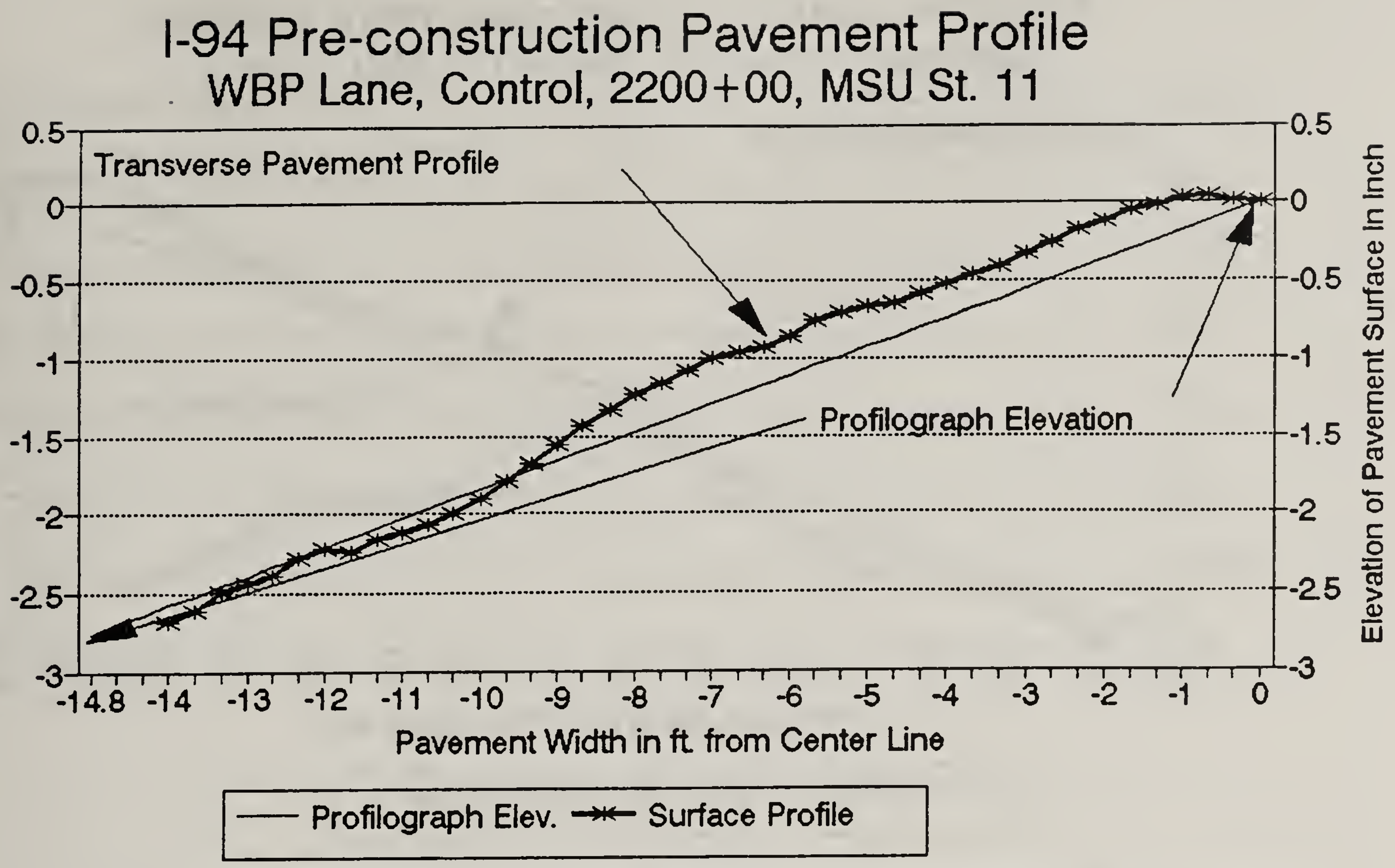


Figure 5B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Pre-construction Pavement Profile
WBP Lane, Control, 2200+00, MSU St. 11

Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

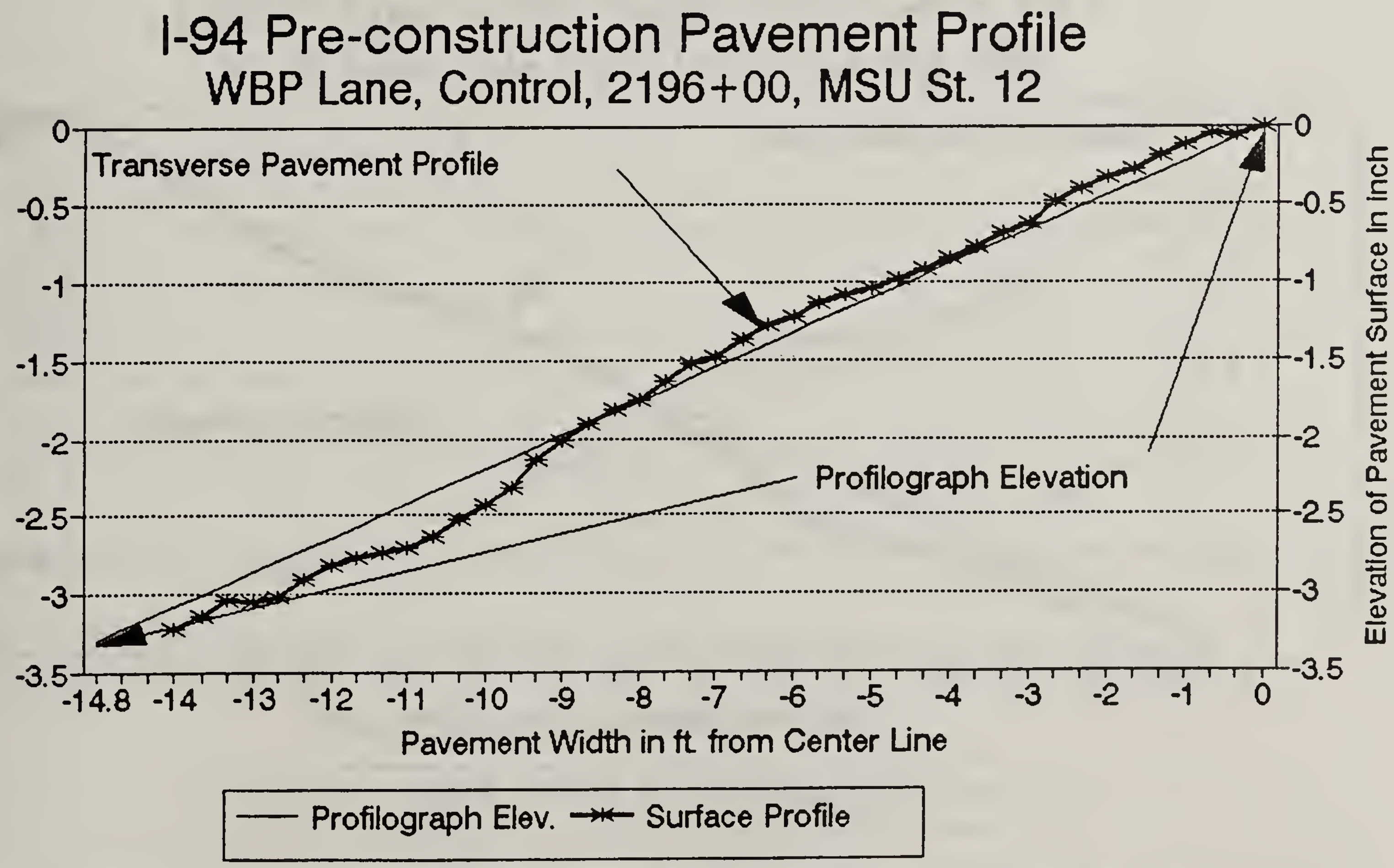
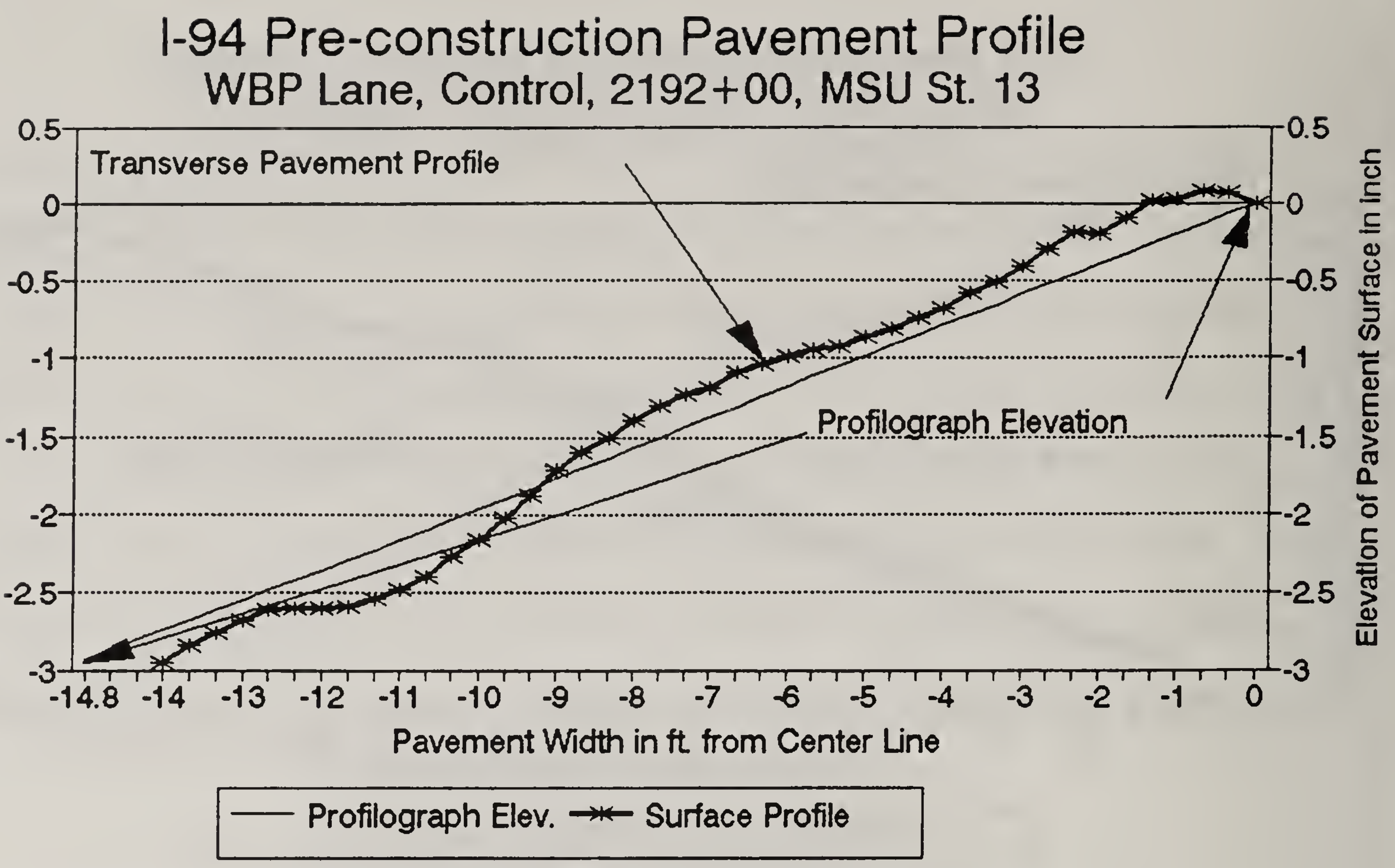

I-94 Pre-construction Pavement Profile
WBP Lane, Control, 2196+00, MSU St. 12

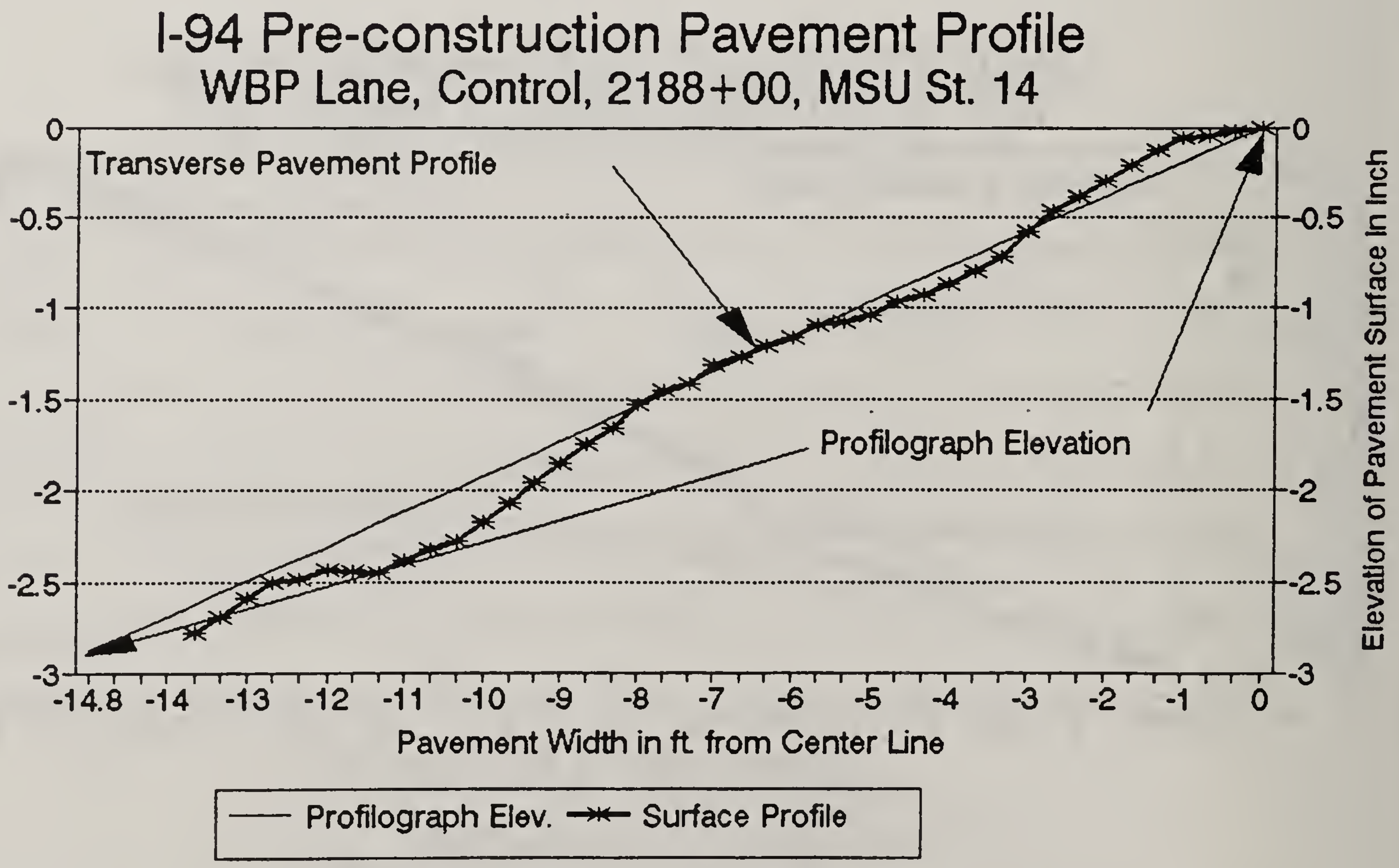
Figure 6B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



I-94 Pre-construction Pavement Profile

WBP Lane, Control, 2192+00, MSU St. 13

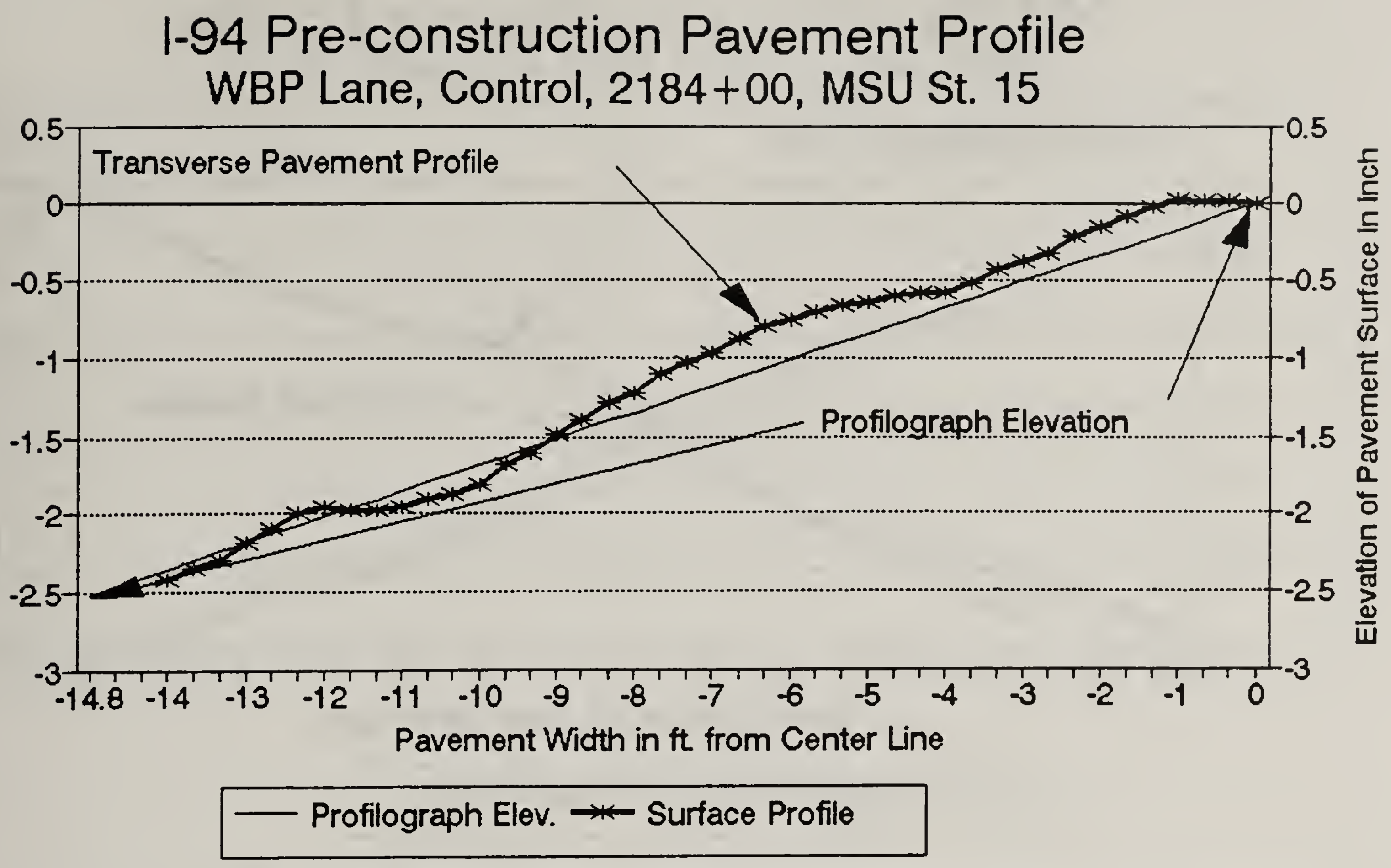
Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon



I-94 Pre-construction Pavement Profile

WBP Lane, Control, 2188+00, MSU St. 14

Fig. 7B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

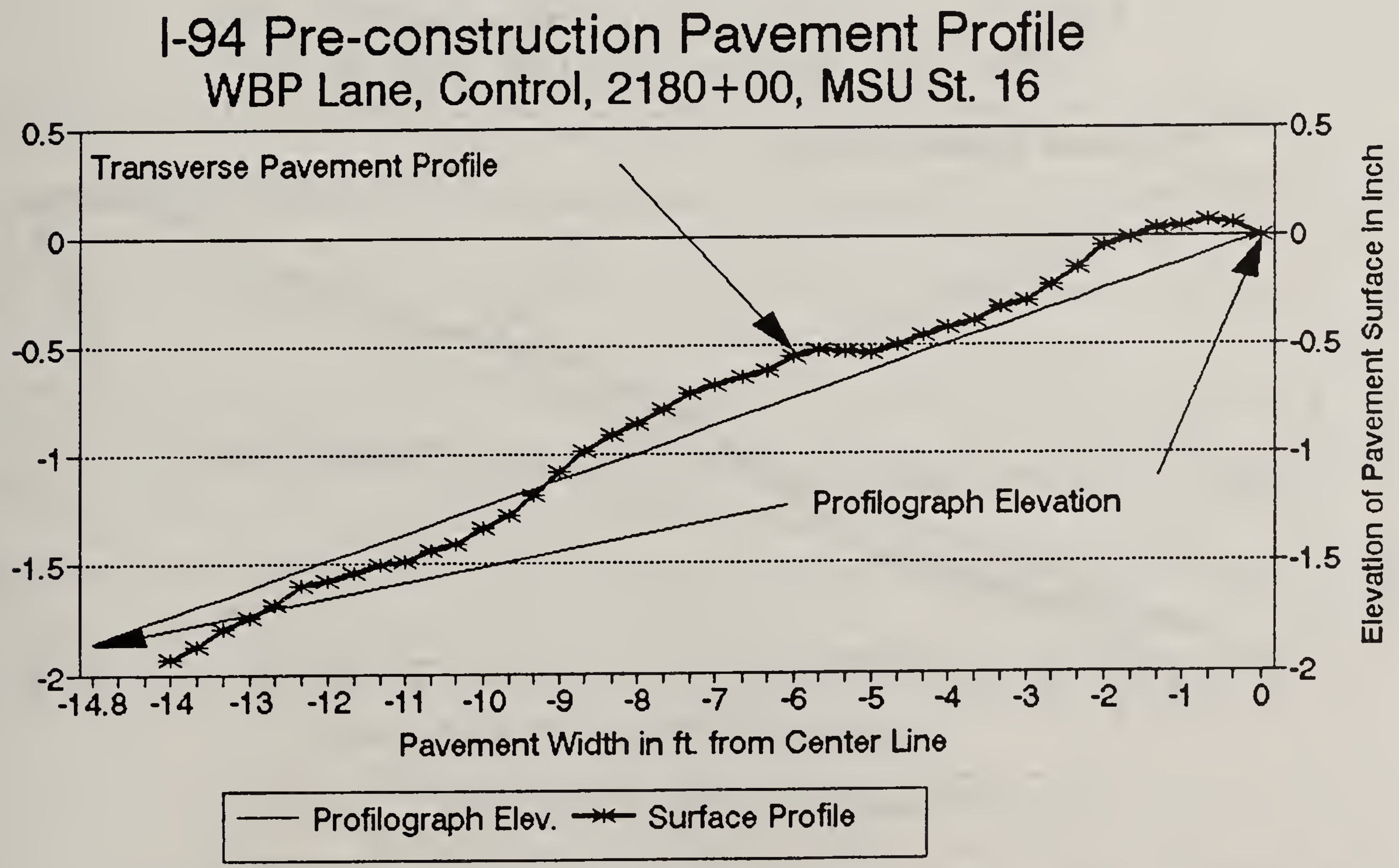
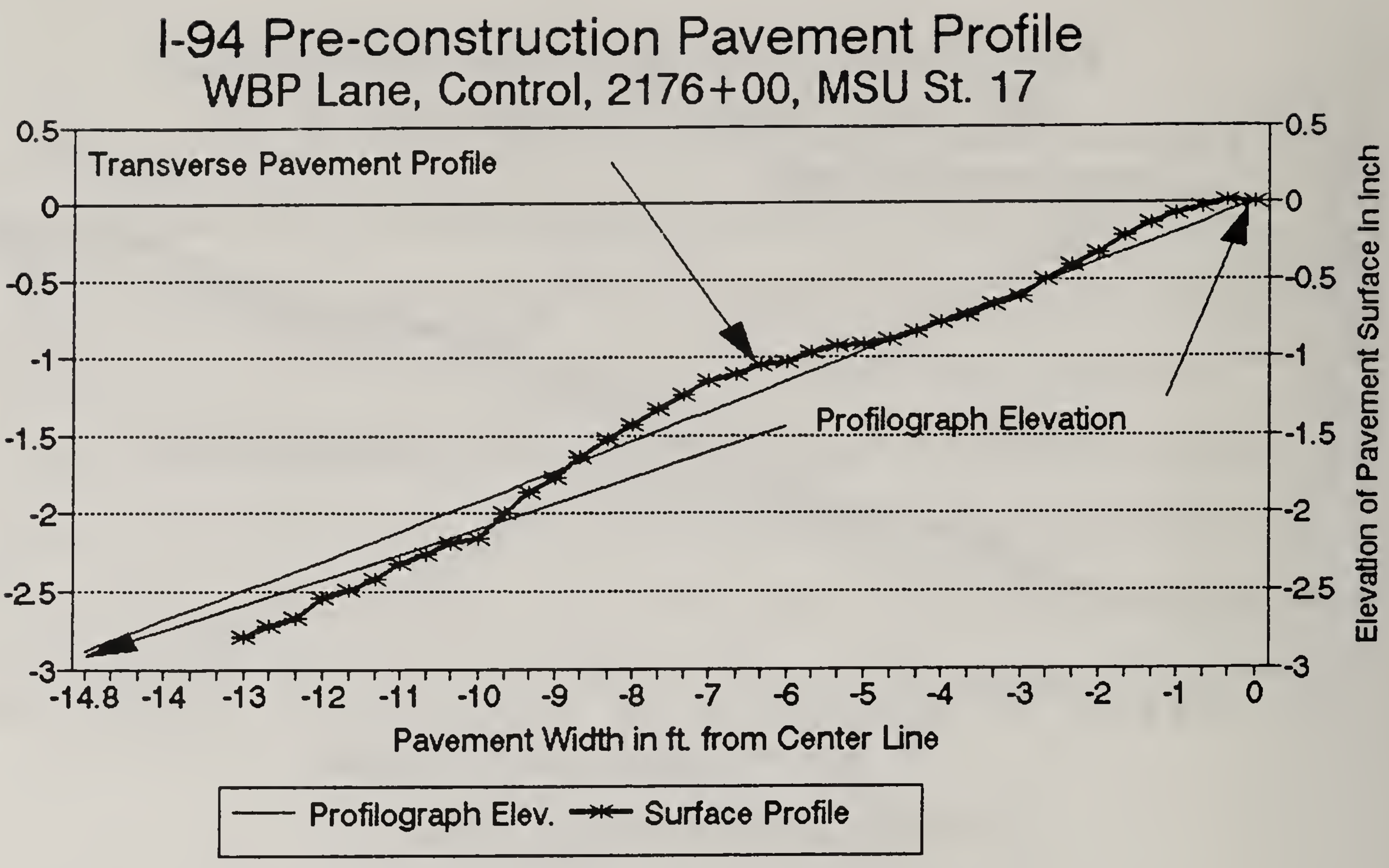


Fig. 8B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

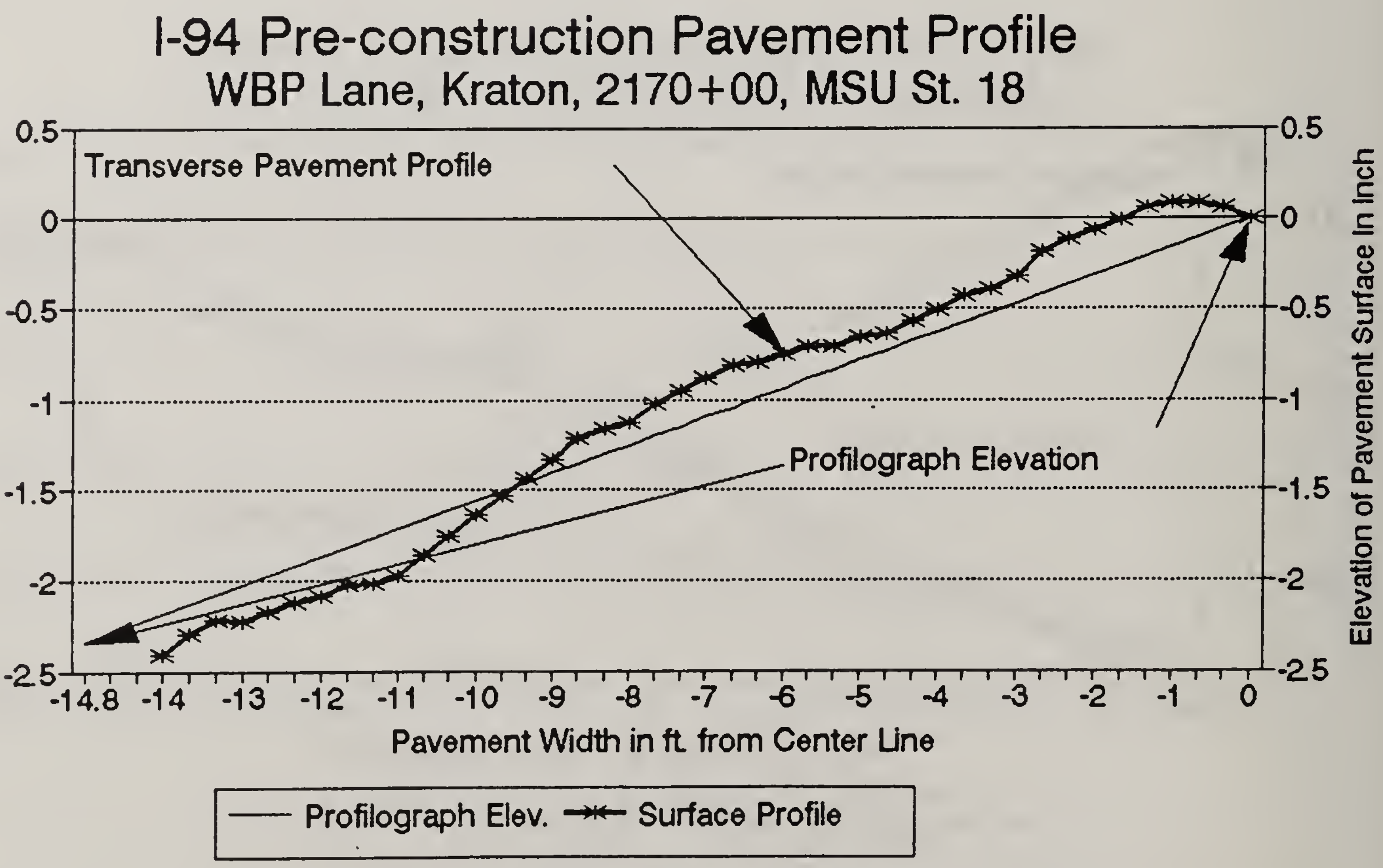
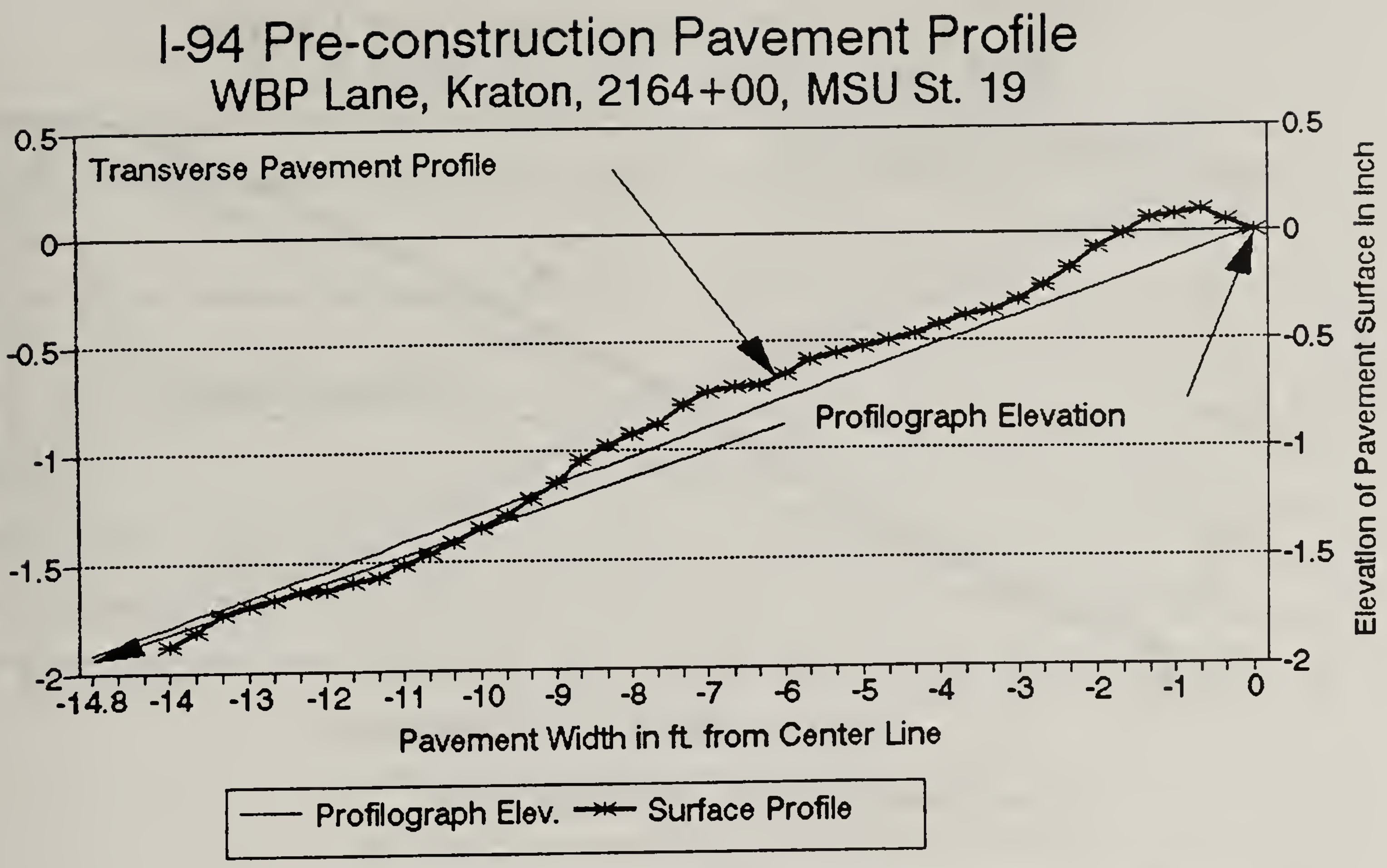


Fig. 9B. Pre-construction Profile and Elevation, Center line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Kraton Modified Binder Section

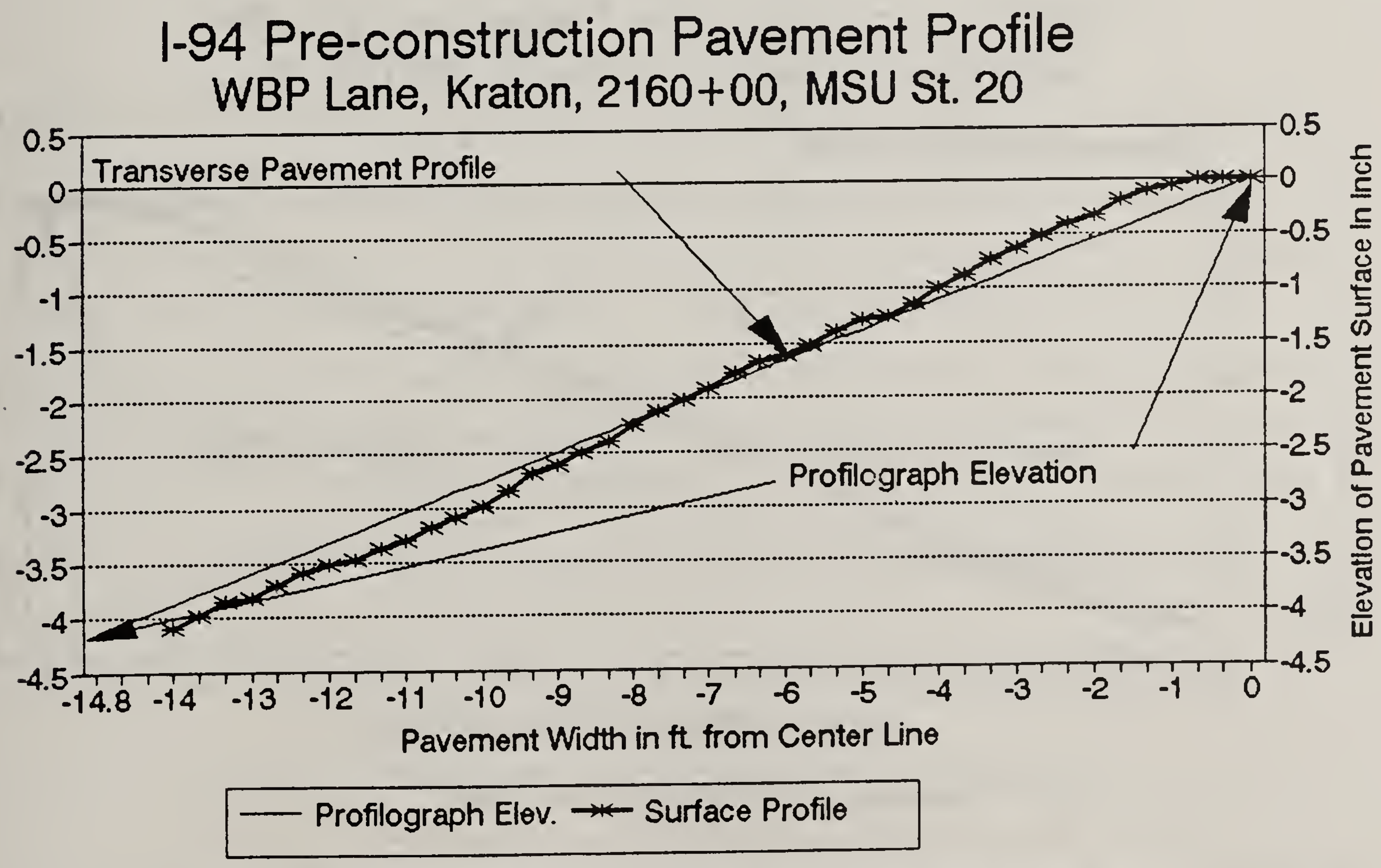
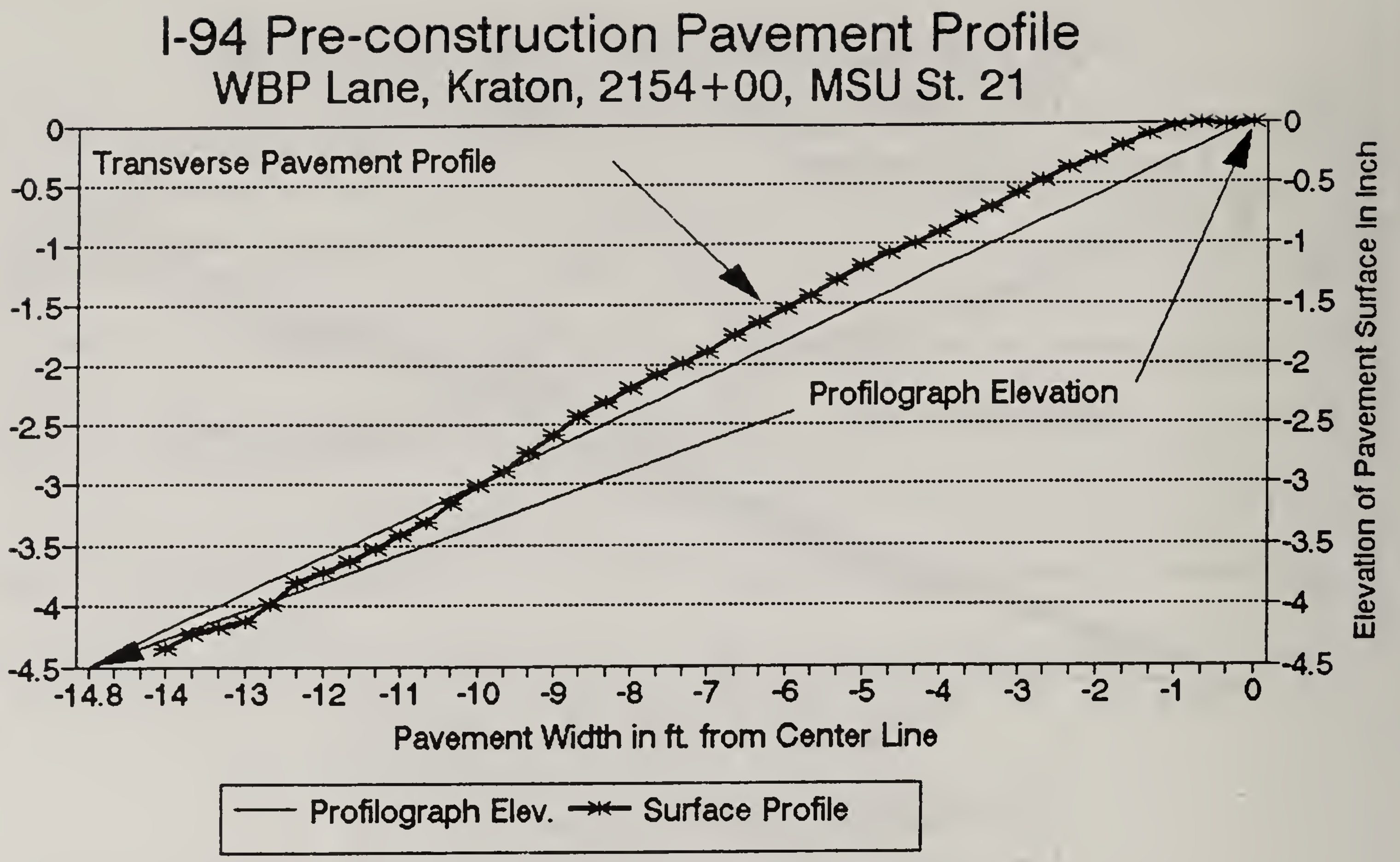


Fig. 10B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Kraton Modified Binder Section

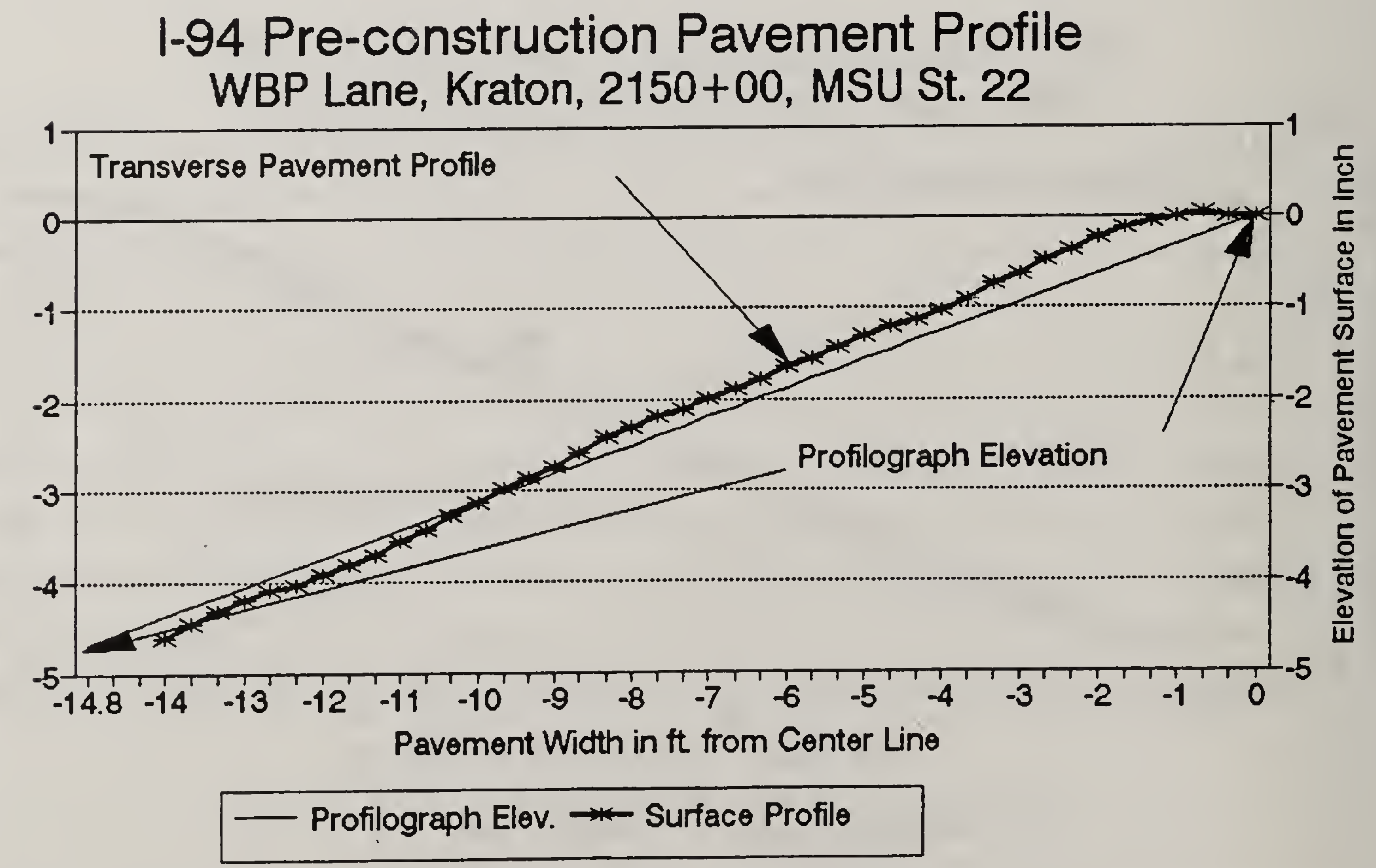
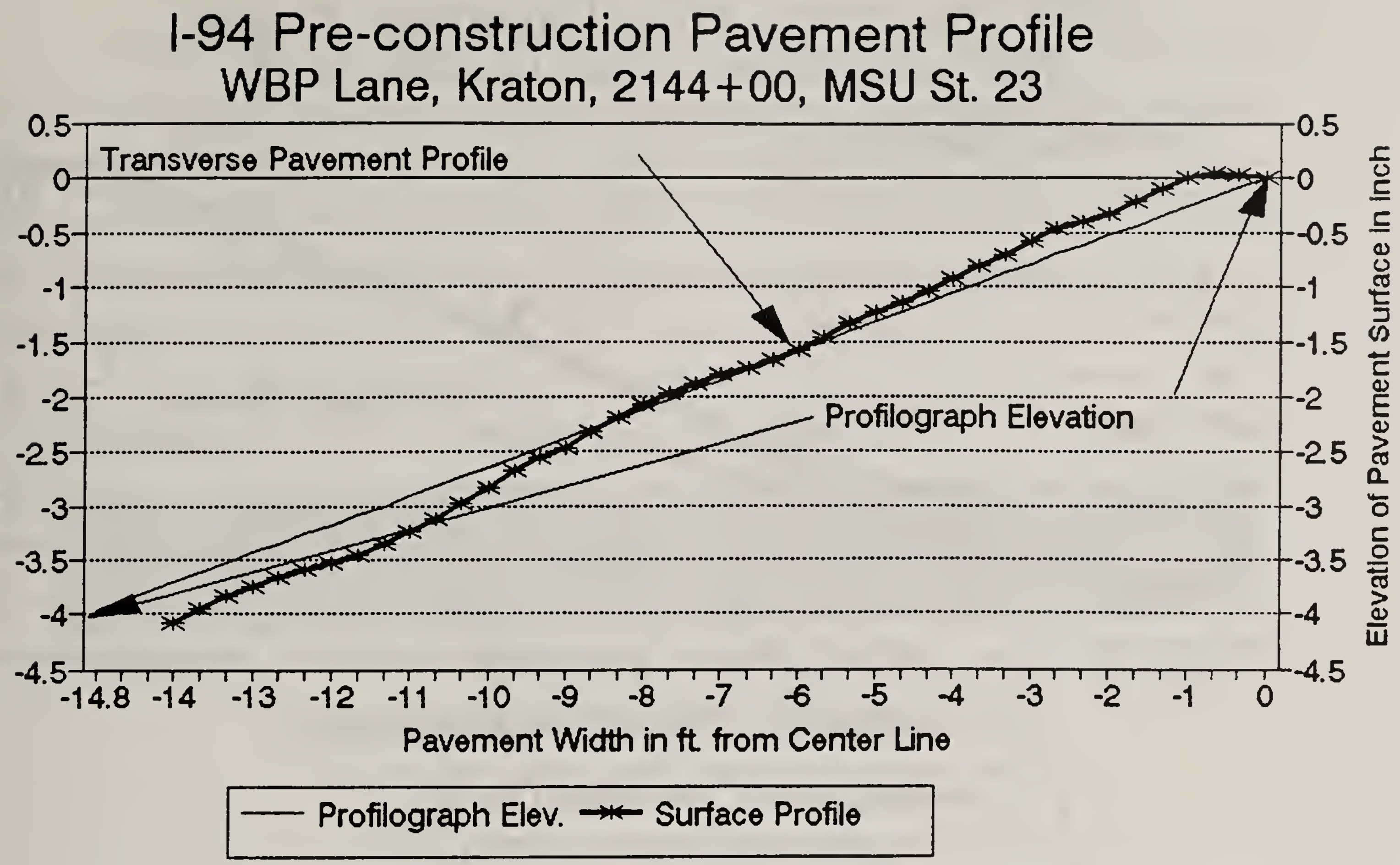


Fig. 11B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Kraton Modified Binder Section

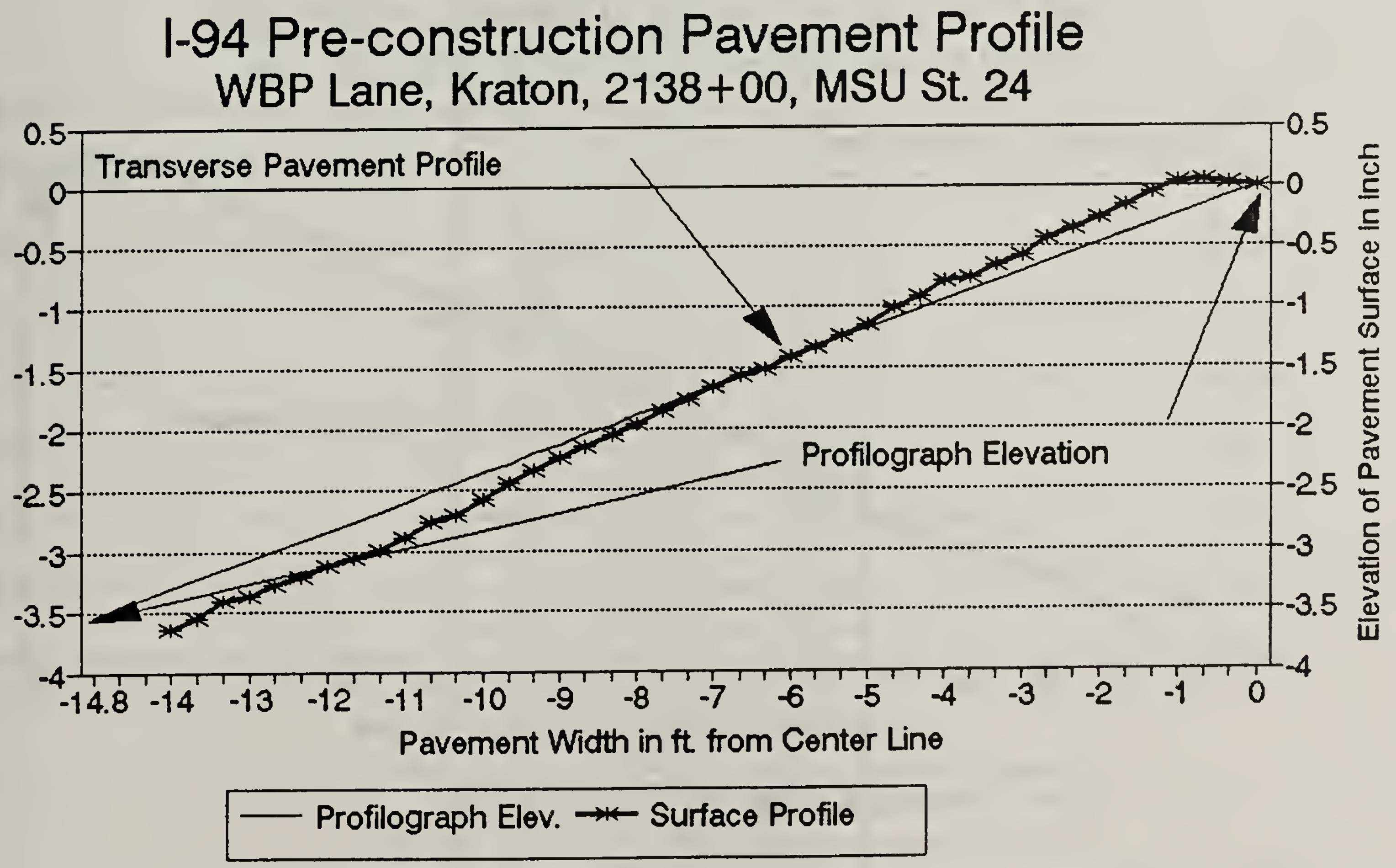
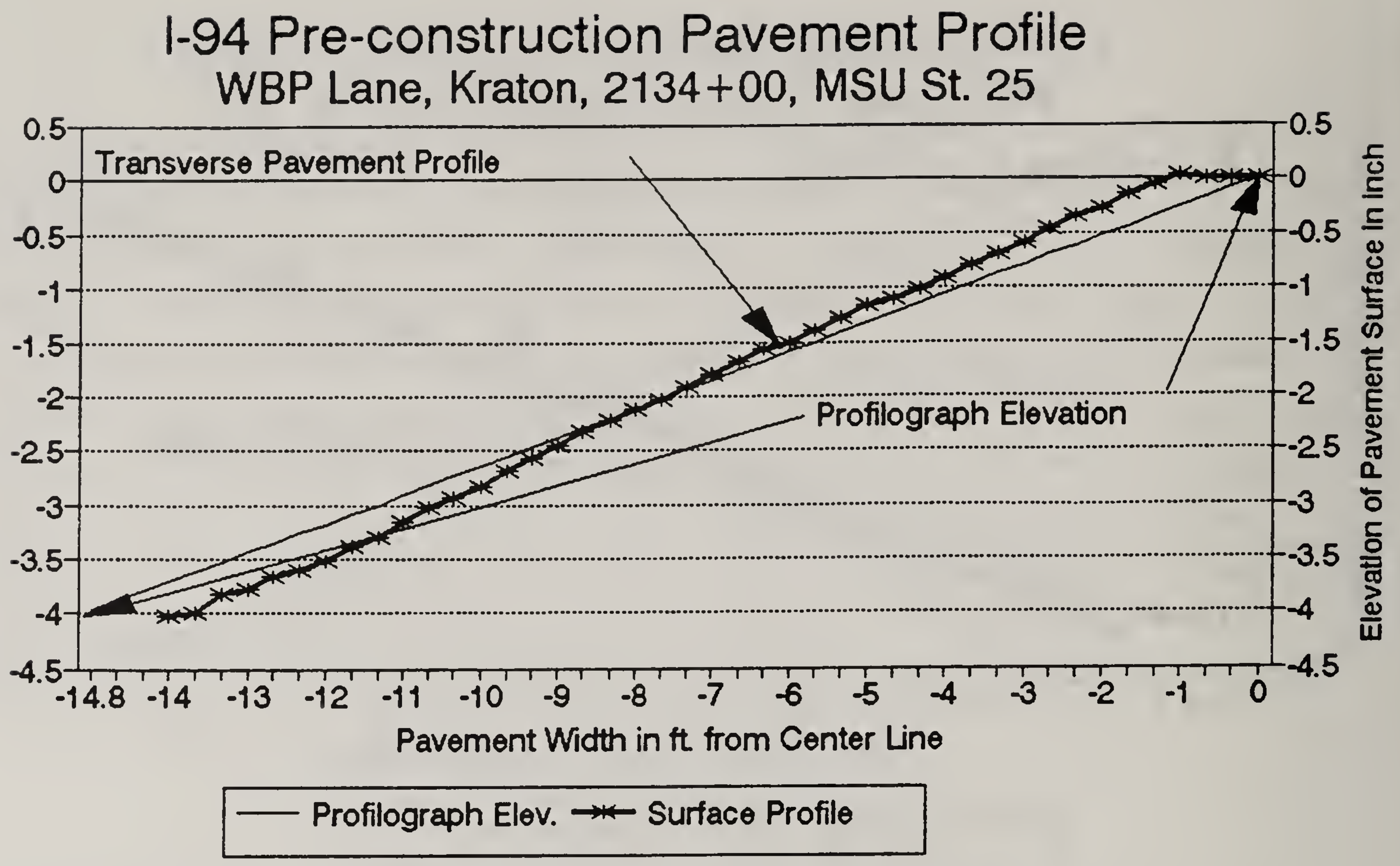


Fig. 12B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Kraton Modified Binder Section

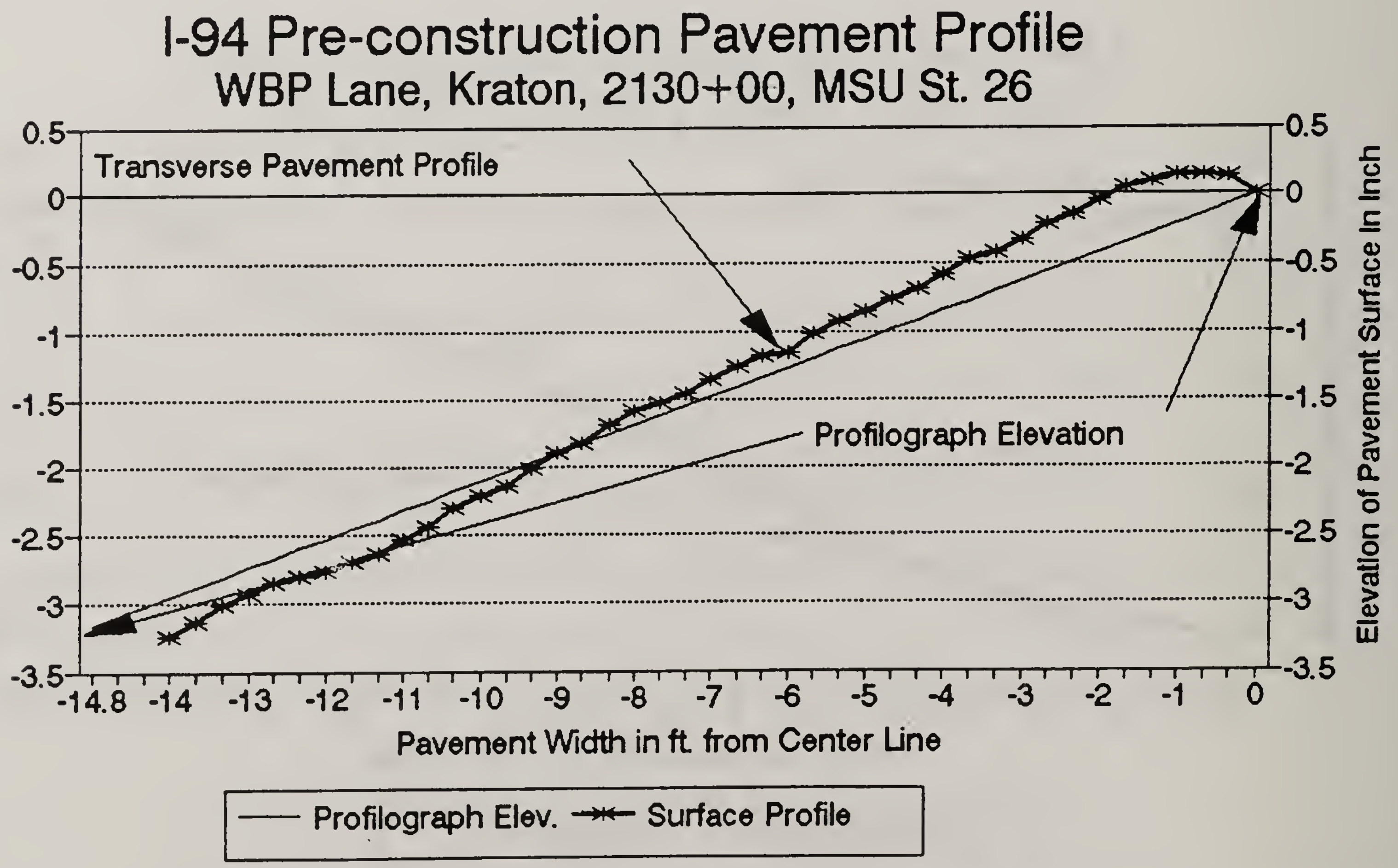
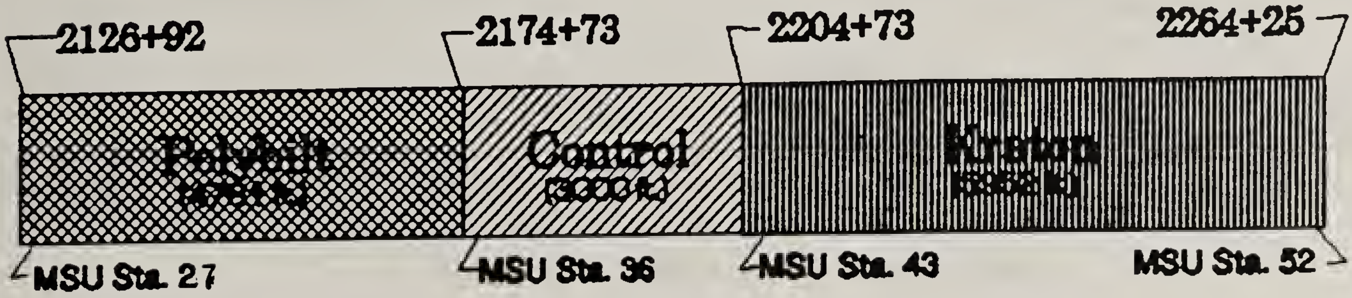


Fig. 13B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin

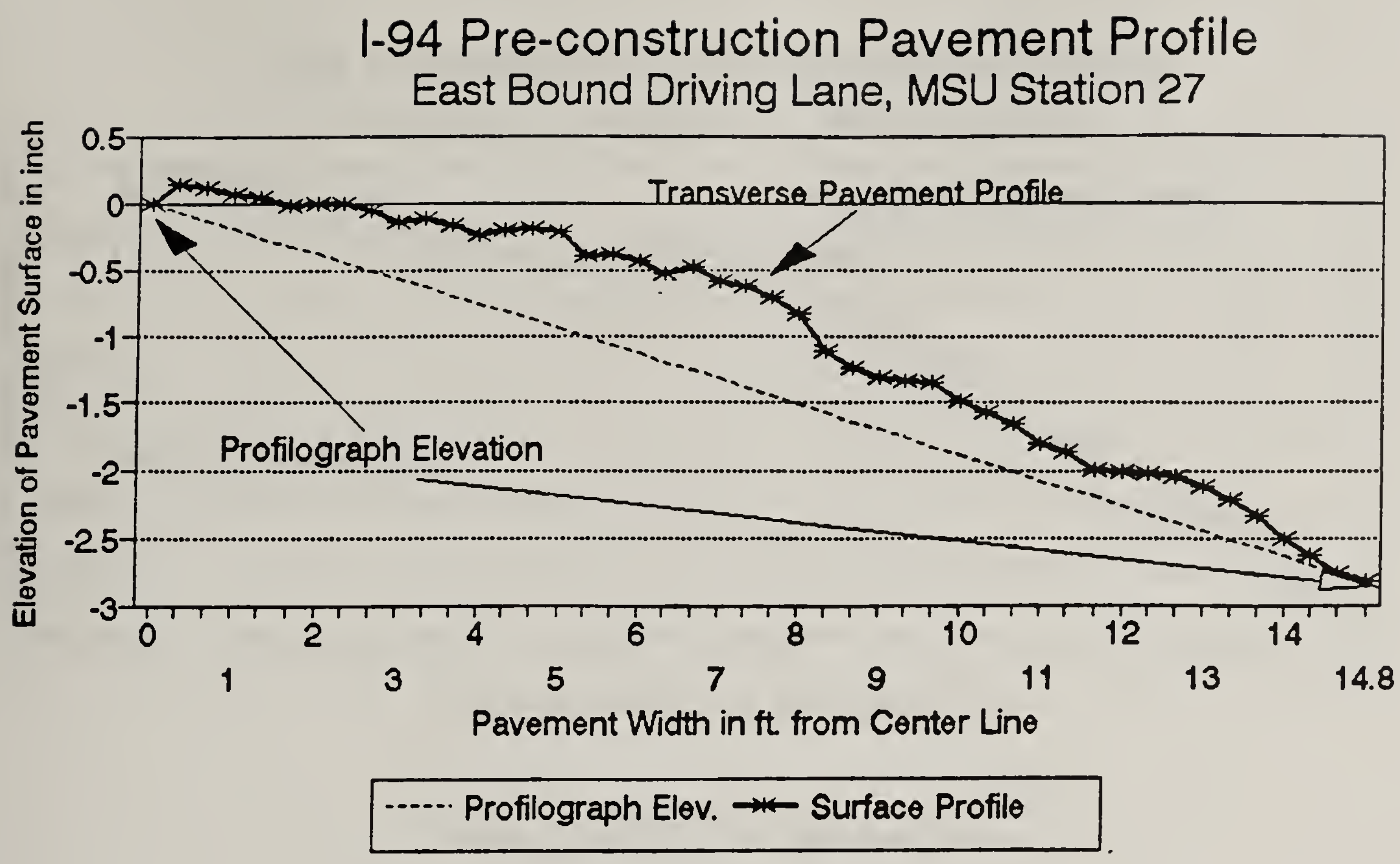
Appendix H

- Figures 14A through 26A - Pre-construction Pavement Profile and Elevation of East Bound Driving Lane
- Figures 14B through 26B - Pre-construction Pavement Profile and Elevation of East Bound Passing Lane

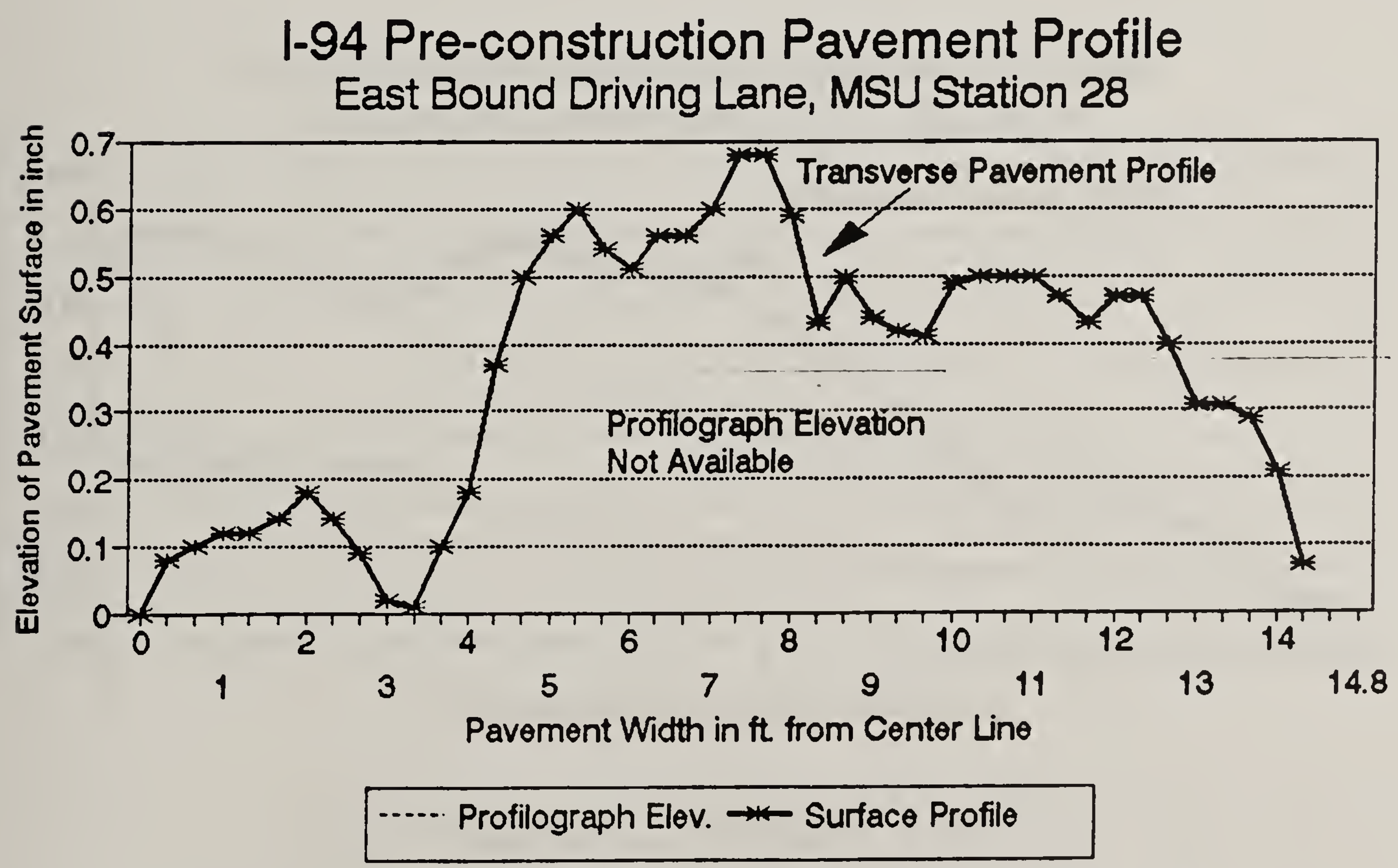


East Bound Interstate Highway I-94

MSU Station Number	Highway Stations	Section by Binder Used
27	2130+00	Polybilt
28	2134+00	Polybilt
29	2138+00	Polybilt
30	2144+00	Polybilt
31	2150+00	Polybilt
32	2154+00	Polybilt
33	2160+00	Polybilt
34	2164+00	Polybilt
35	2170+00	Polybilt
36	2176+00	Exxon
37	2180+00	Exxon
38	2184+00	Exxon
39	2188+00	Exxon
40	2192+00	Exxon
41	2196+00	Exxon
42	2200+00	Exxon
43	2208+00	Kraton
44	2214+00	Kraton
45	2220+00	Kraton
46	2226+00	Kraton
47	2232+00	Kraton
48	2238+00	Kraton
49	2244+00	Kraton
50	2250+00	Kraton
51	2254+00	Kraton
52	2260+00	Kraton

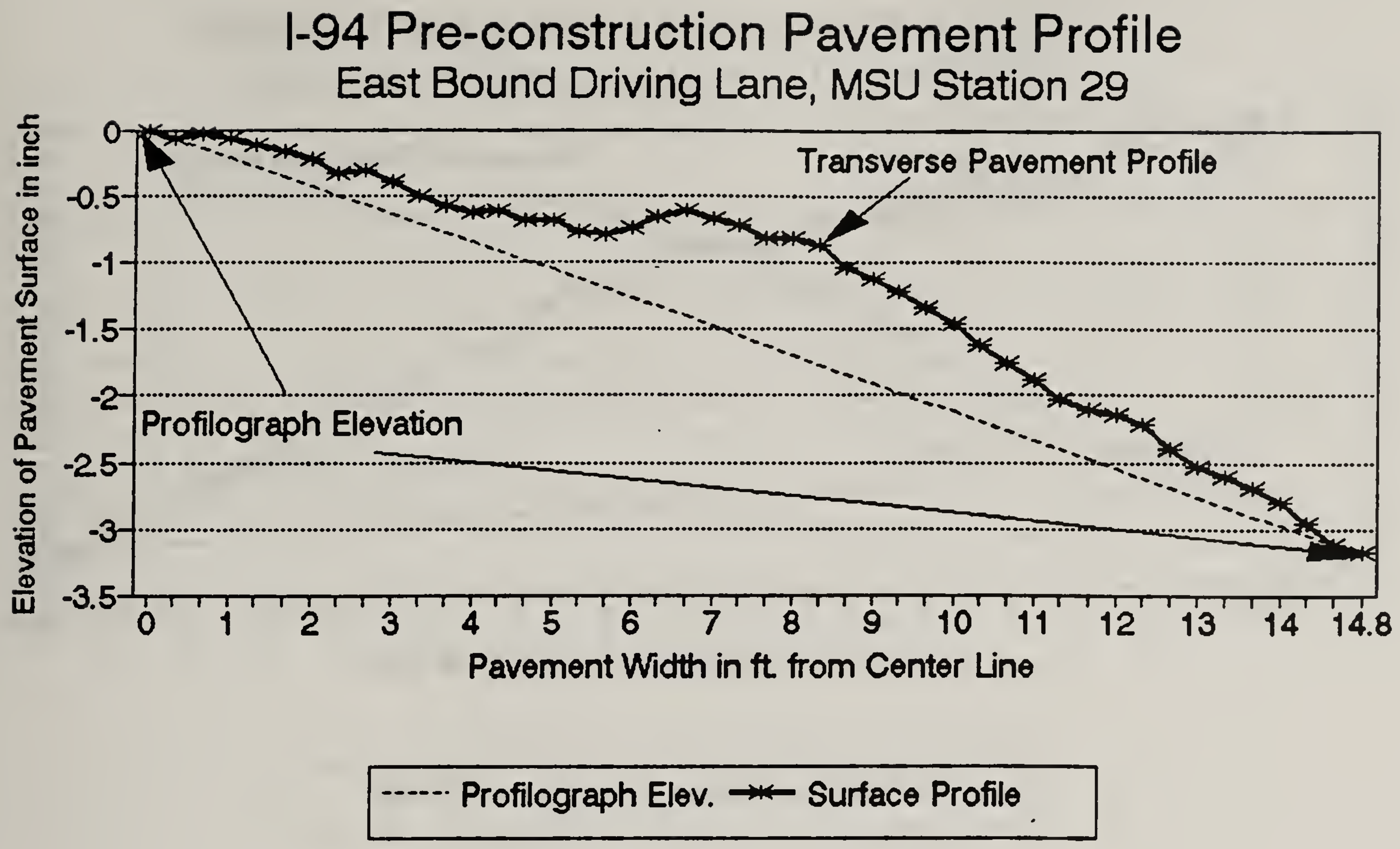


I-94 Pre-construction Pavement Profile
East Bound Driving Lane, MSU Station 27



I-94 Pre-construction Pavement Profile
East Bound Driving Lane, MSU Station 28

Fig. 14A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



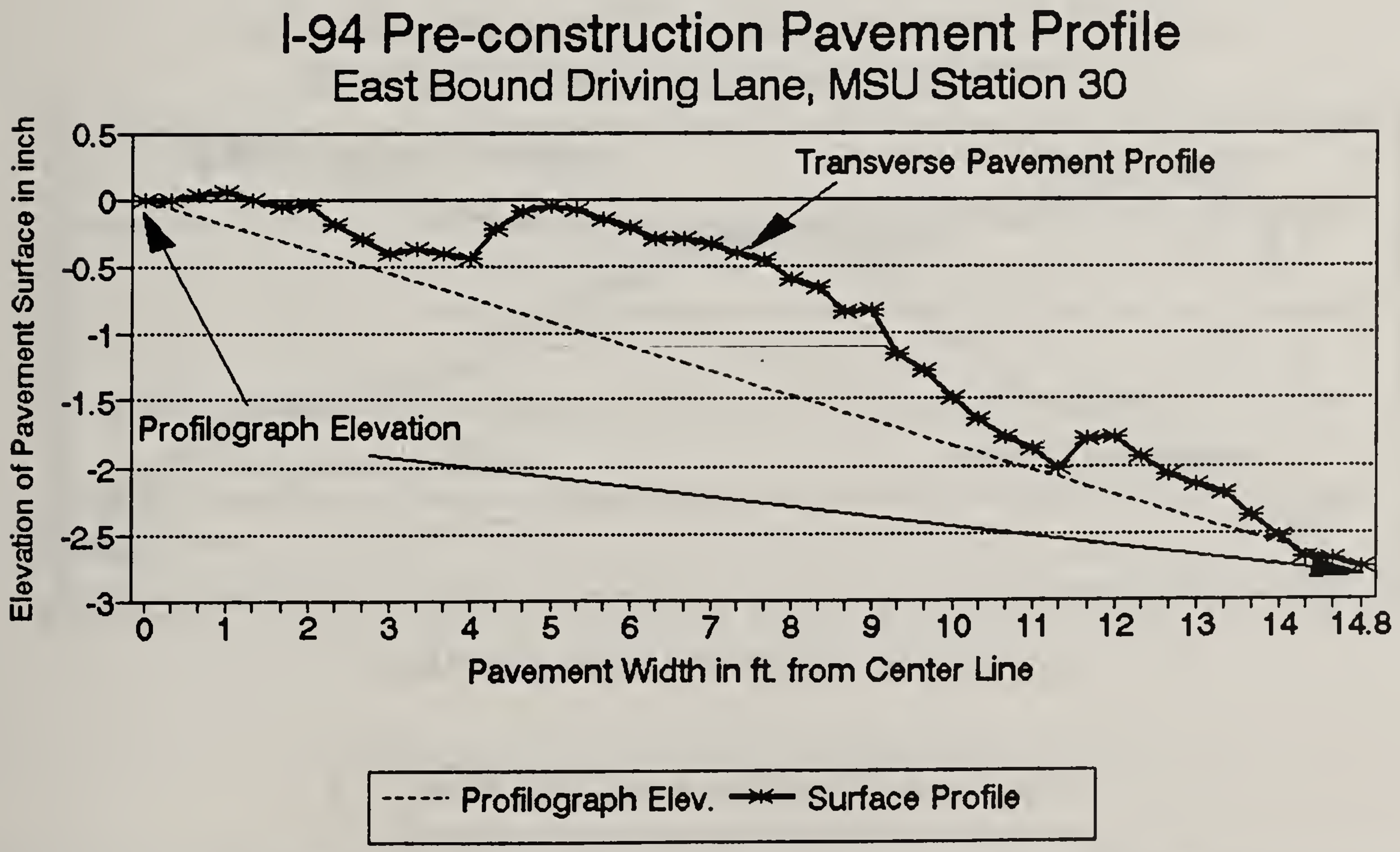
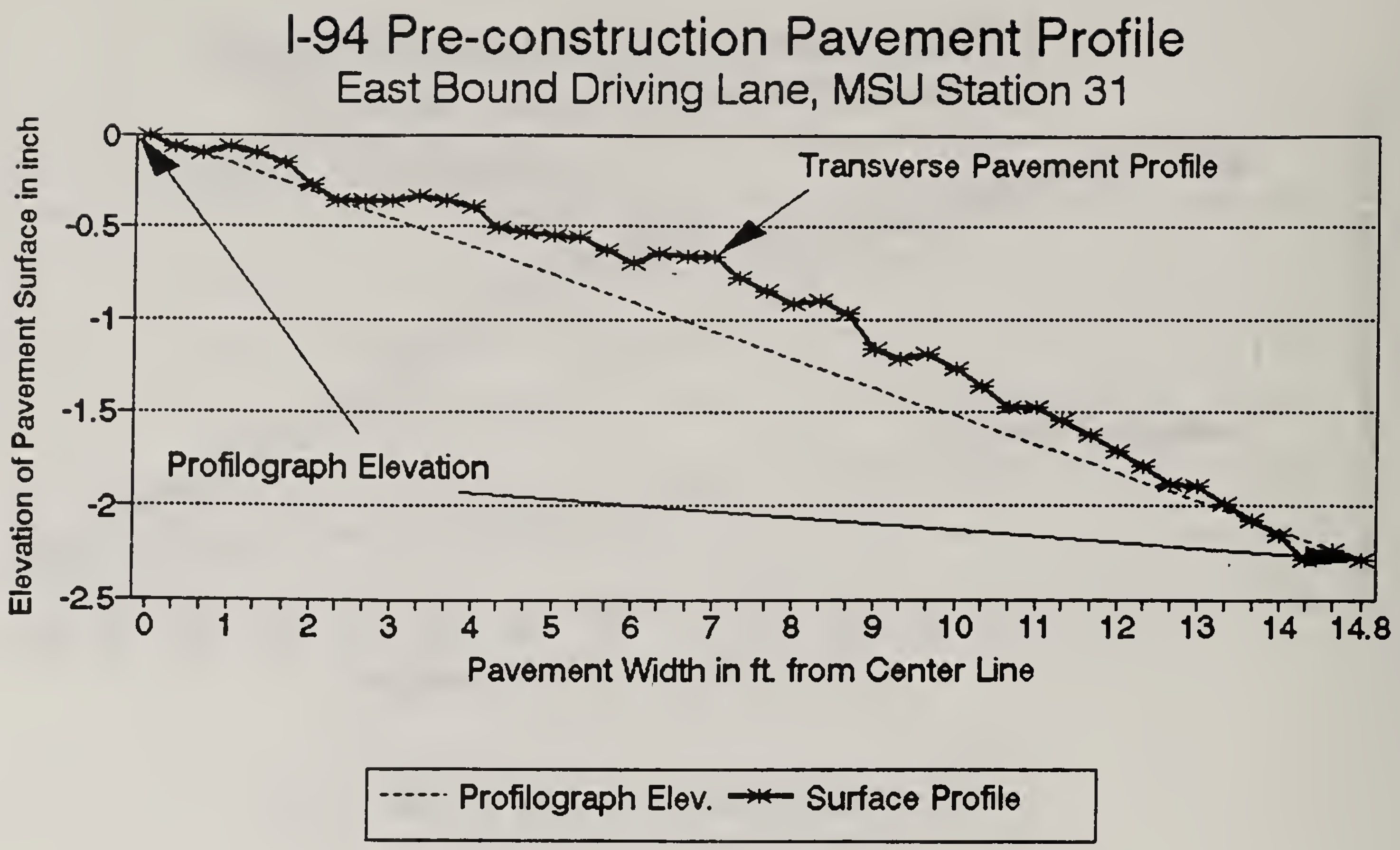


Fig. 15A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



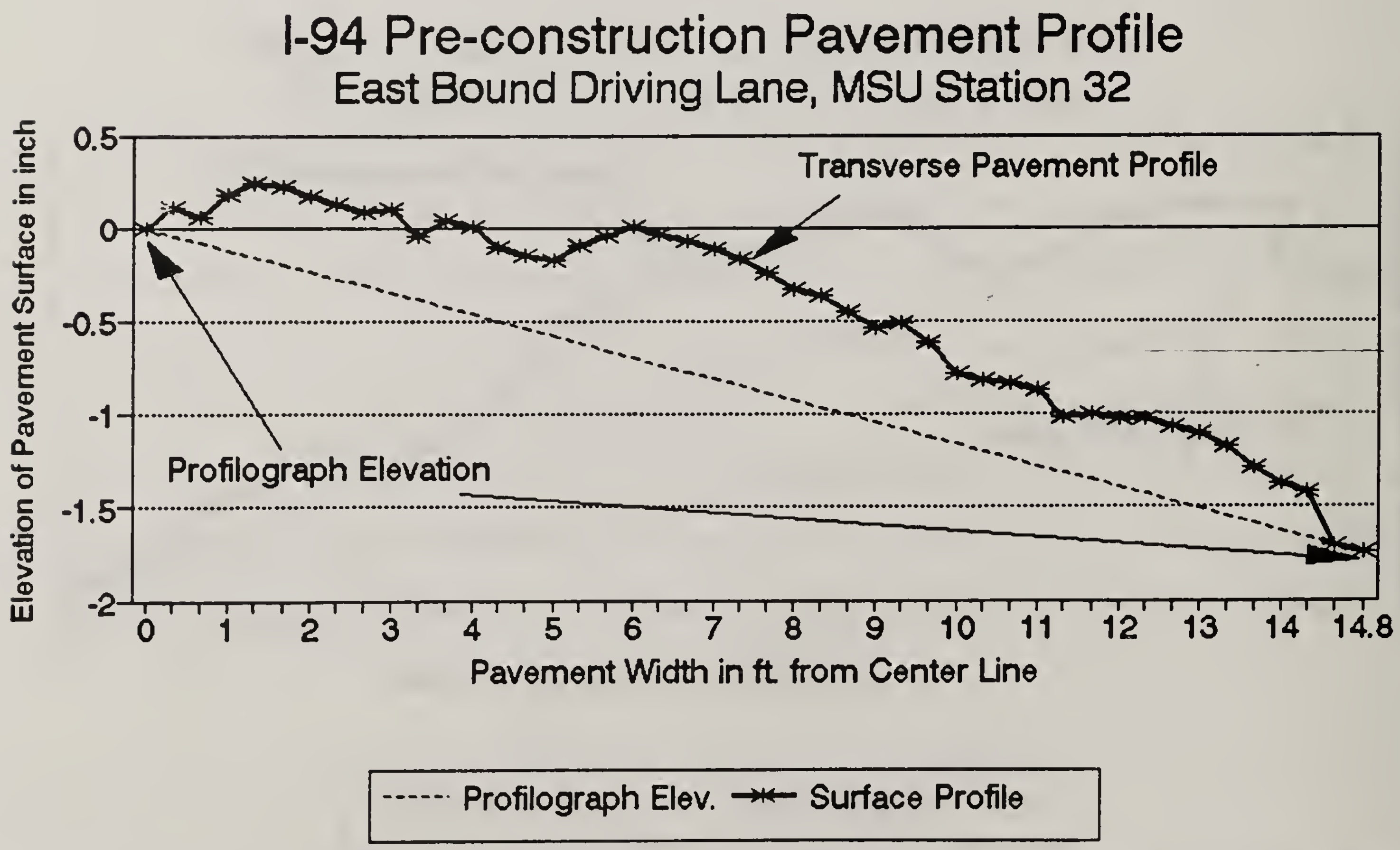
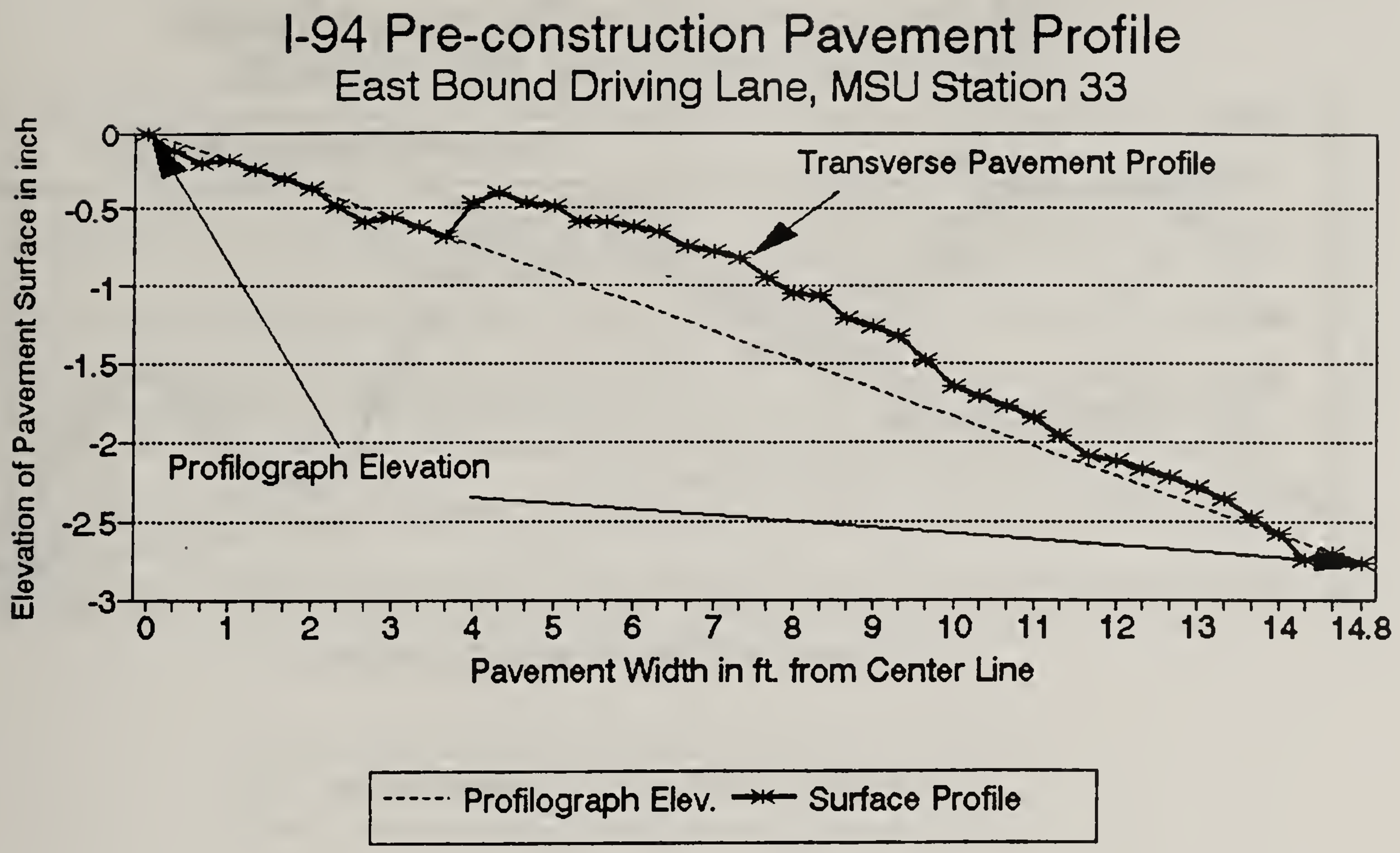


Fig.16A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



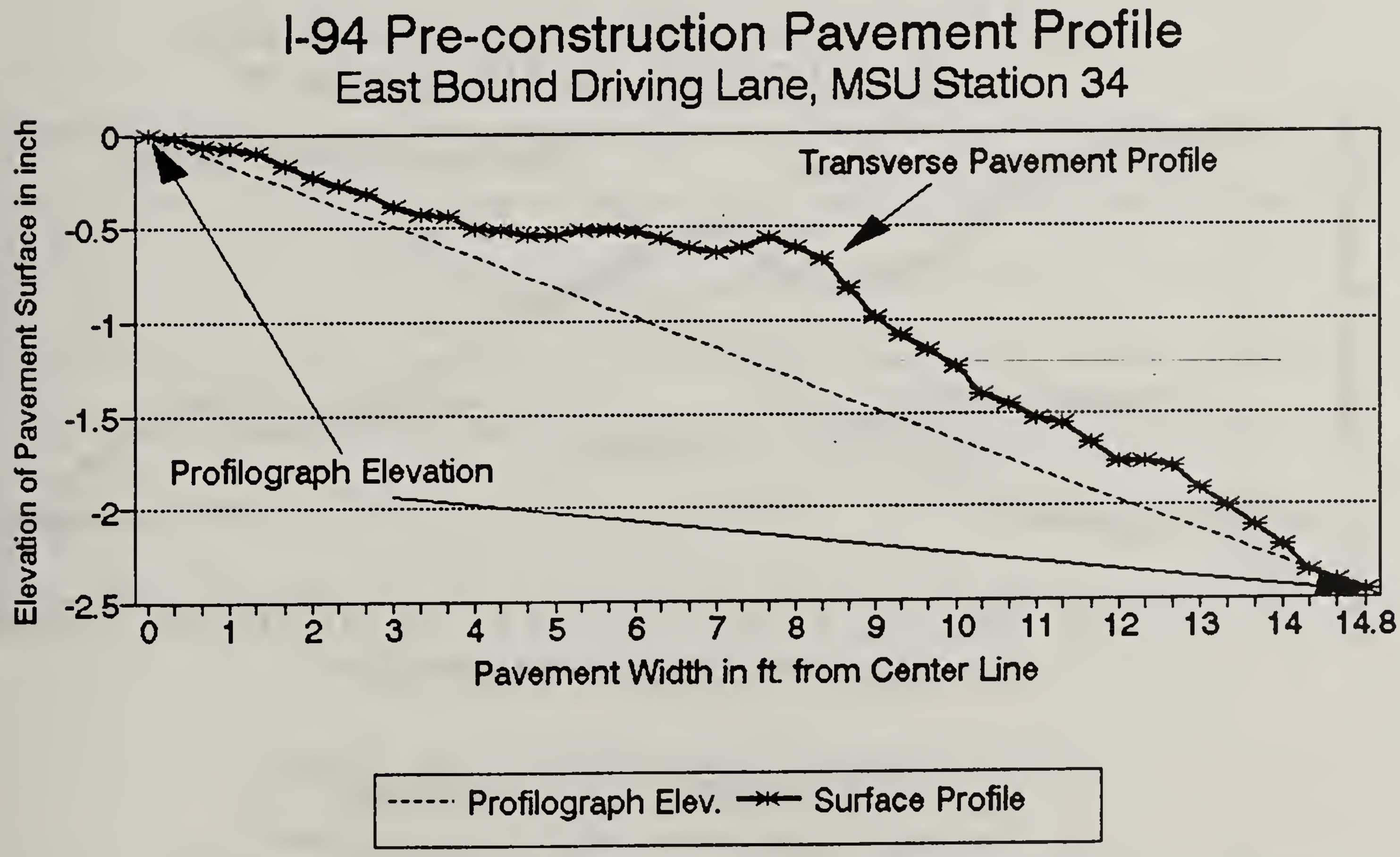
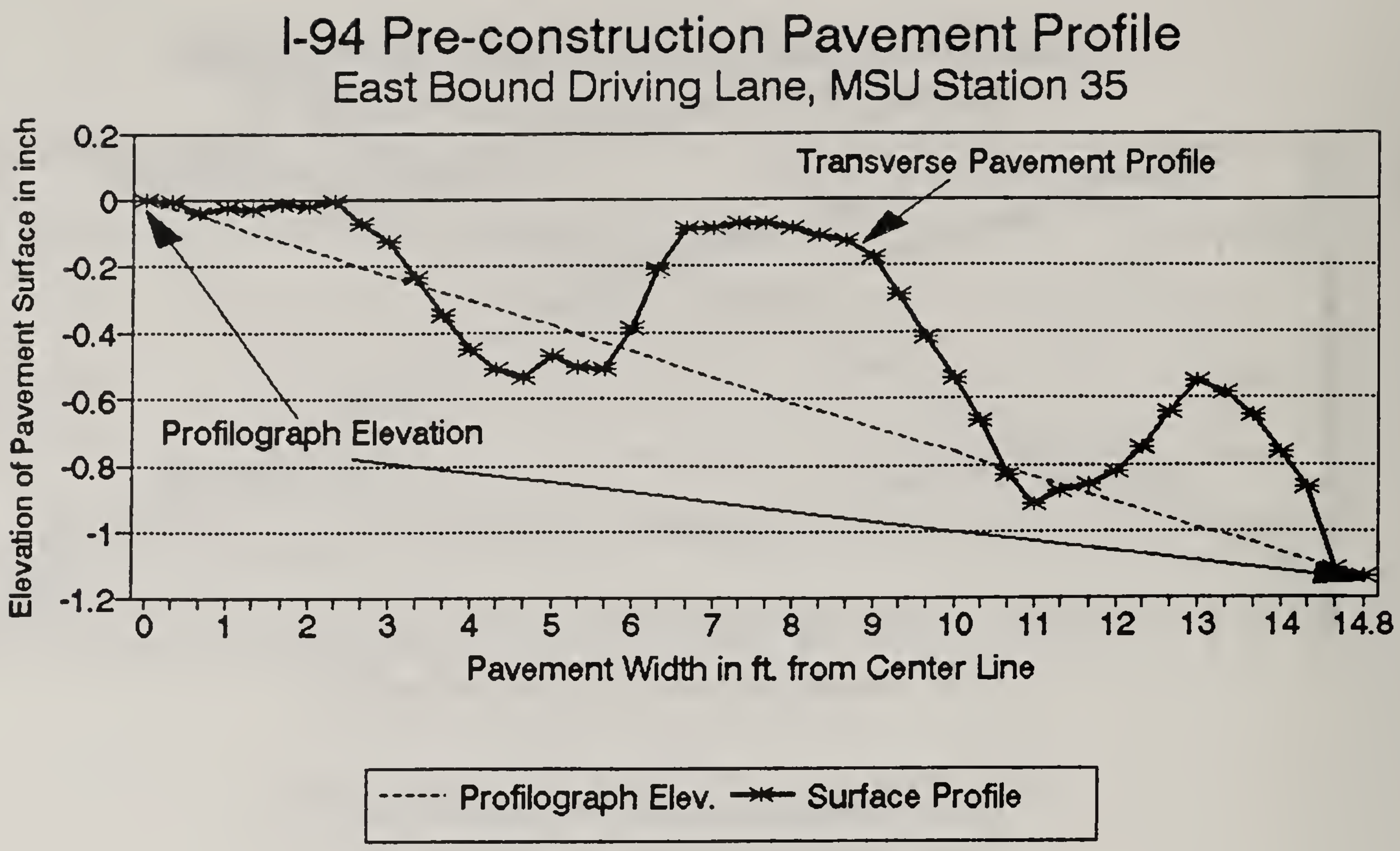


Fig. 17A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



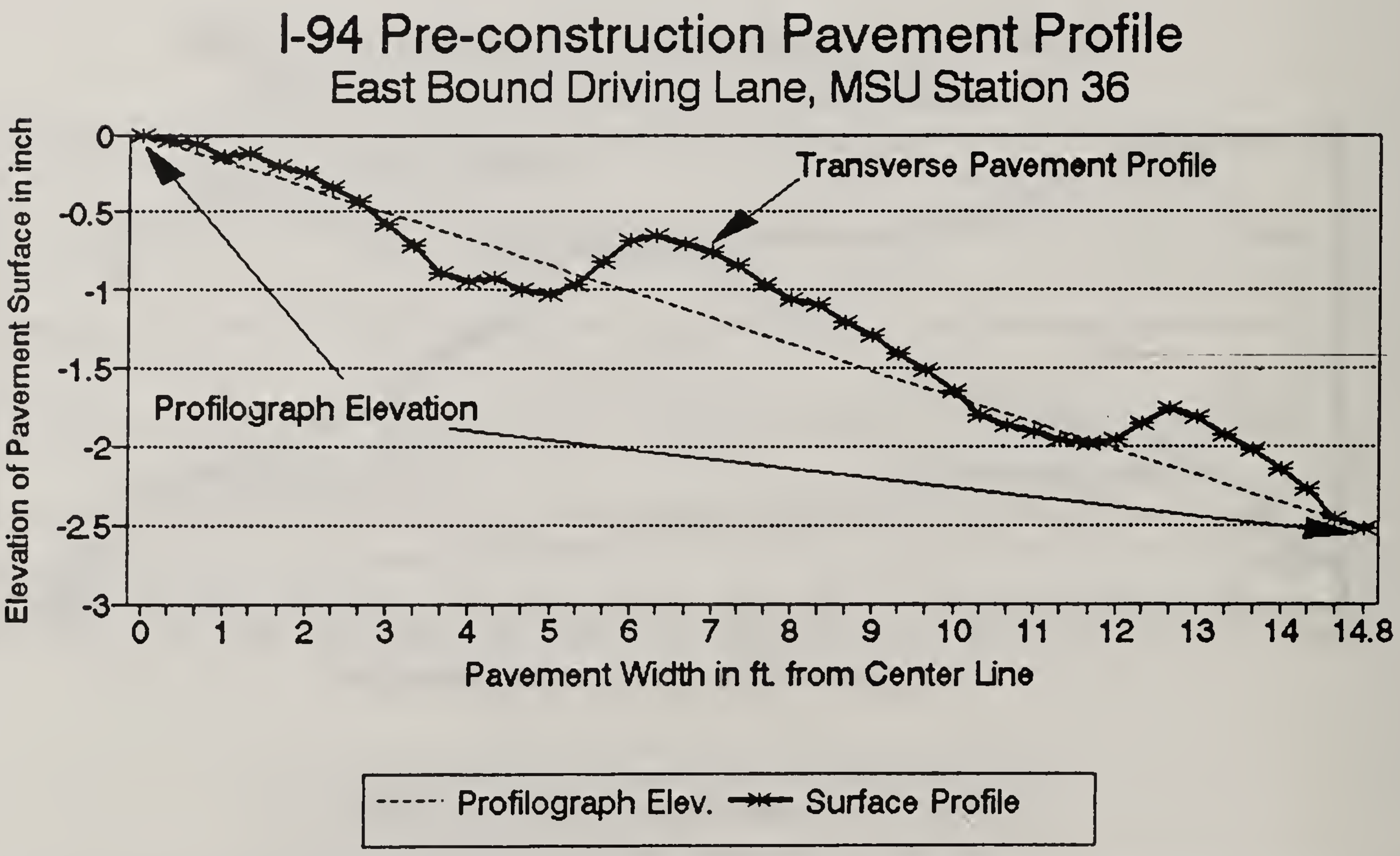


Fig. 18A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin

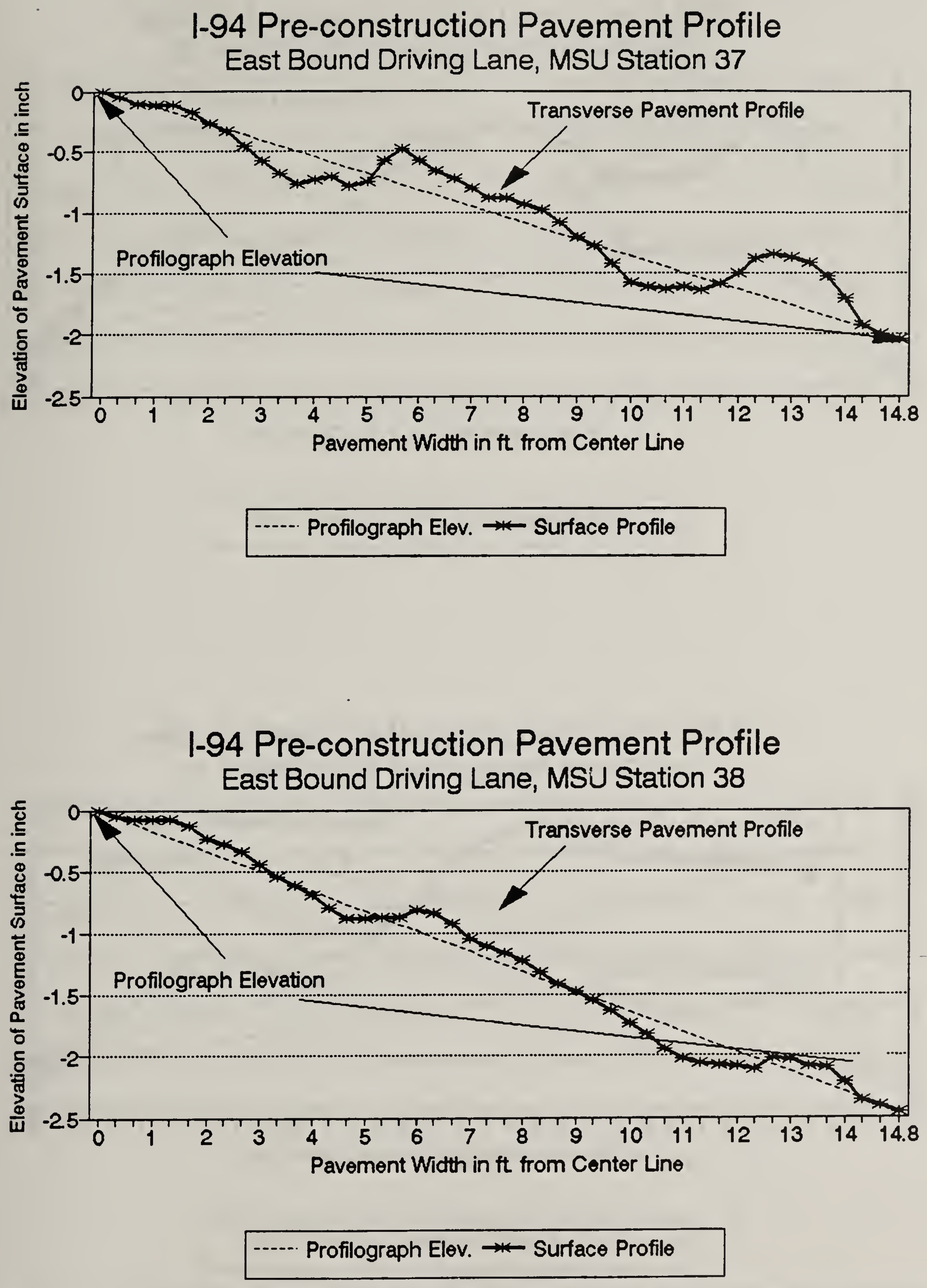


Fig. 19\. Pre-construction Profile and Elevation, Center Line of Pavement as Origin

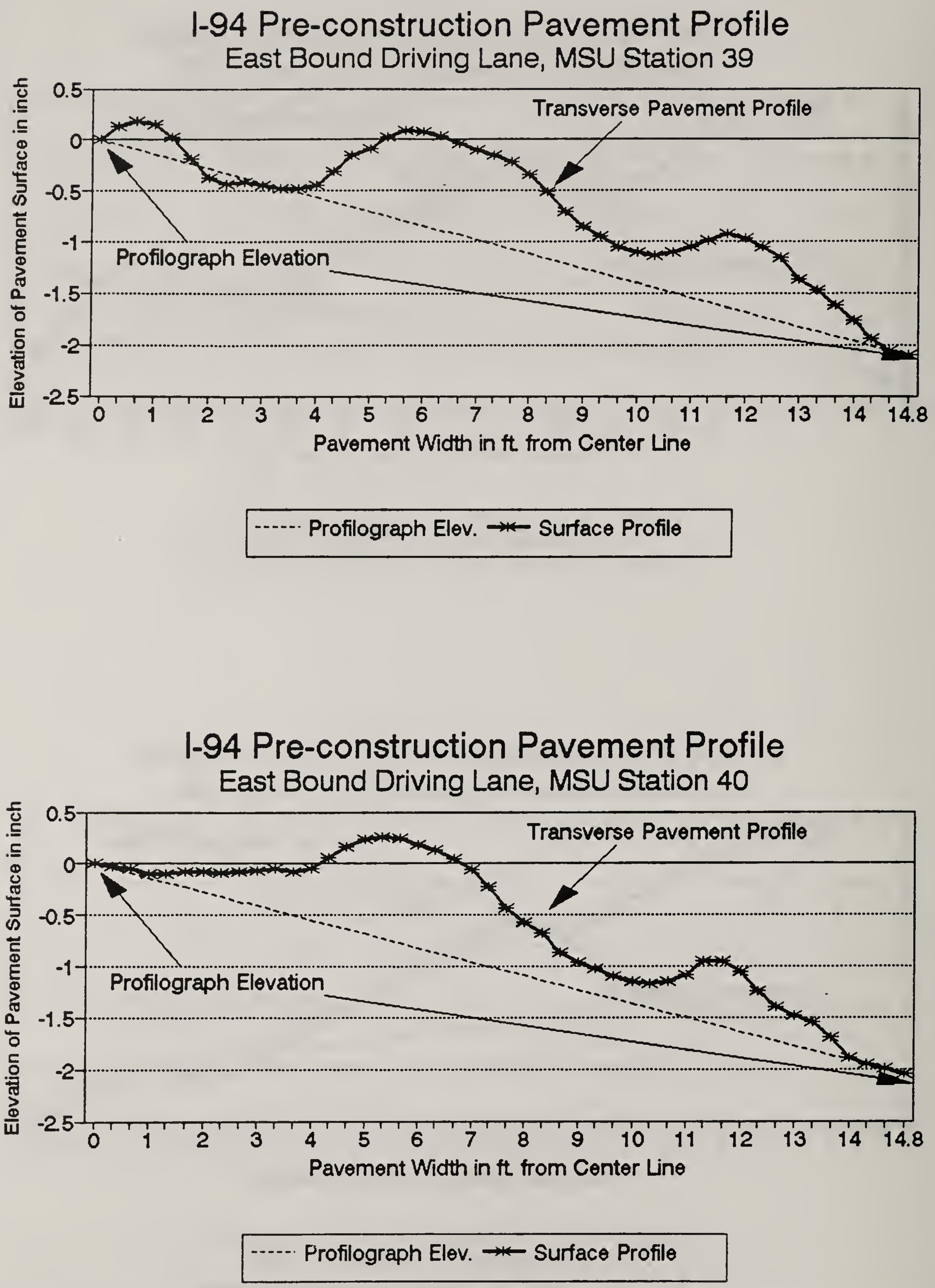
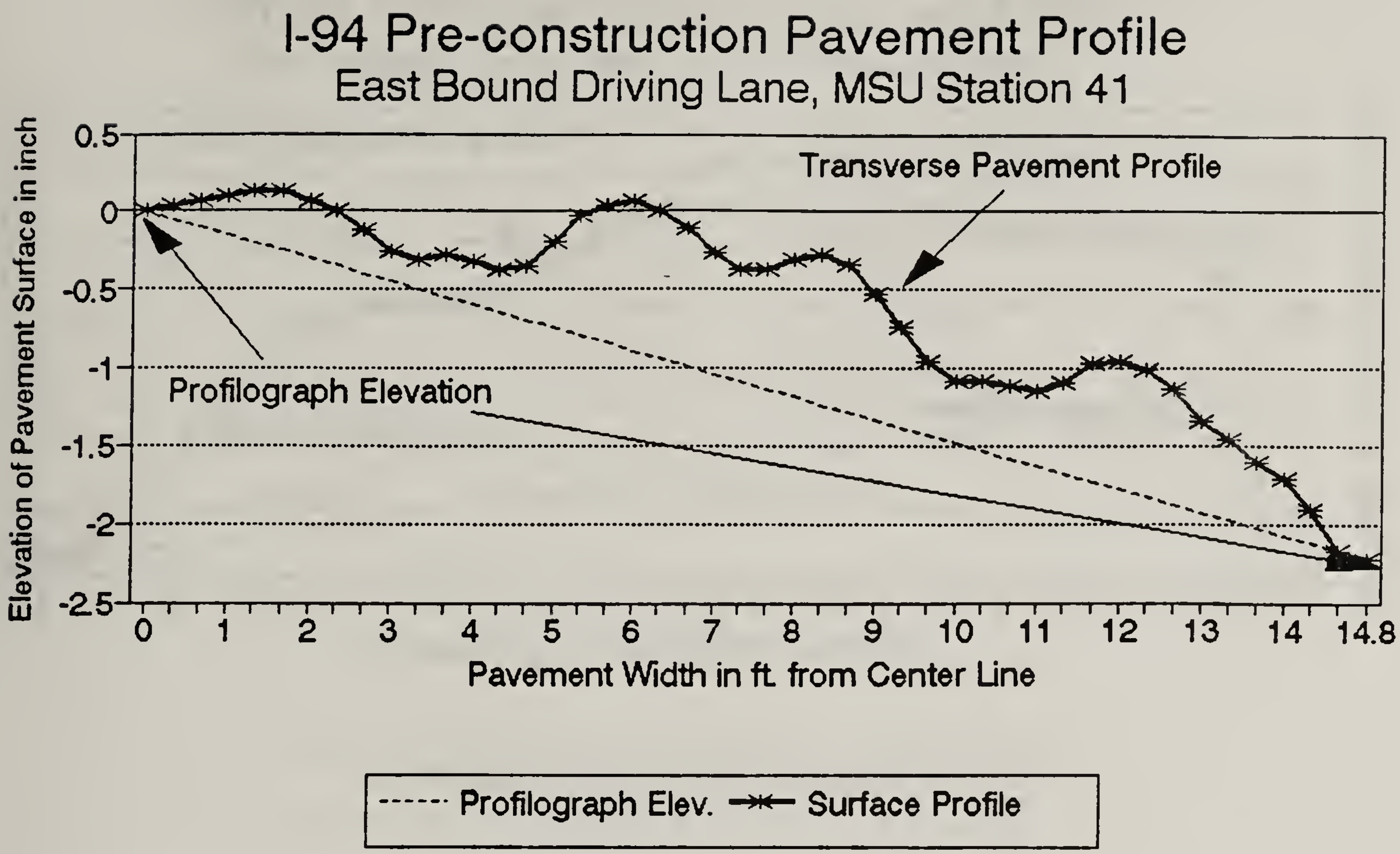
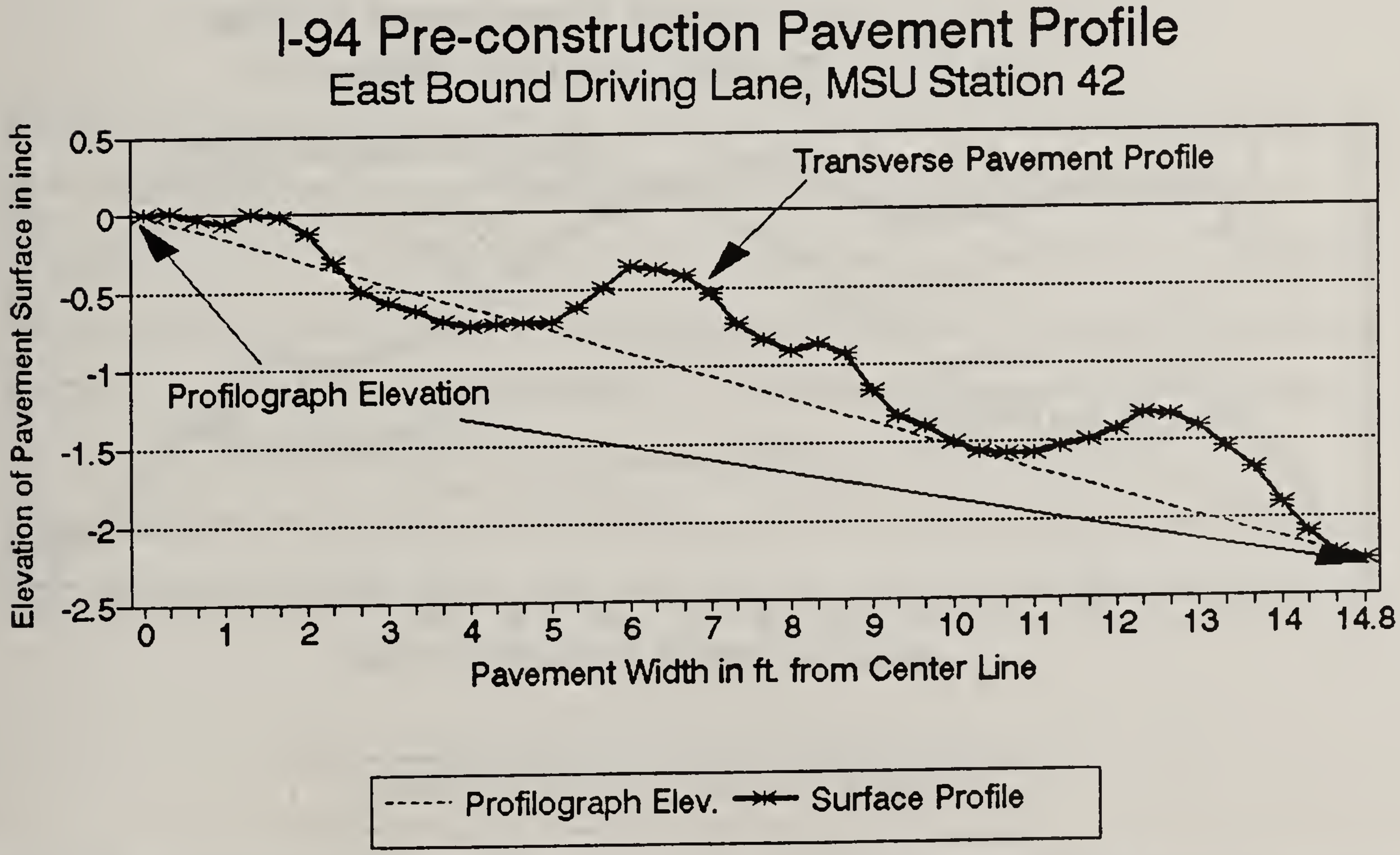


Fig. 20A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin

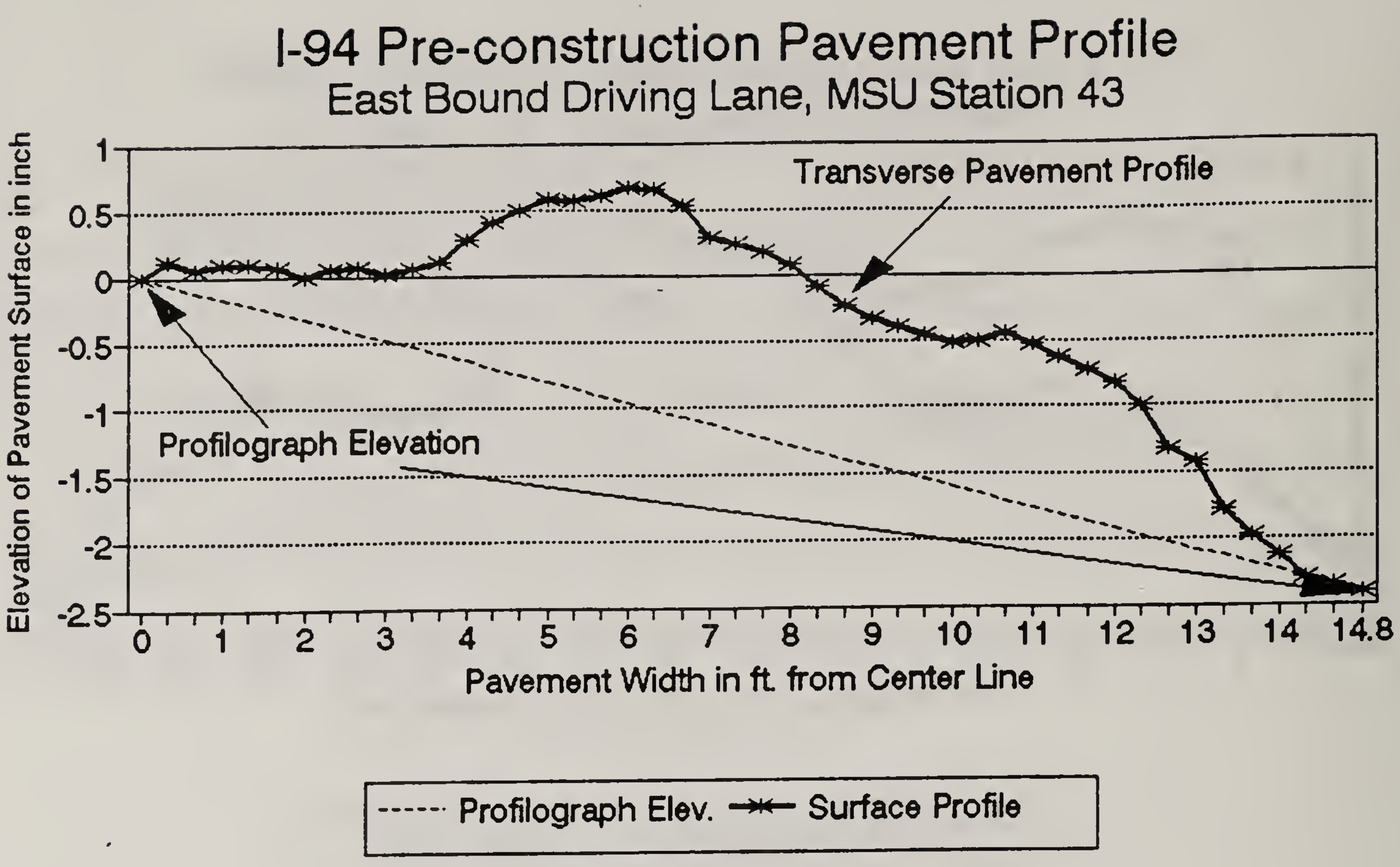


I-94 Pre-construction Pavement Profile
East Bound Driving Lane, MSU Station 41



I-94 Pre-construction Pavement Profile
East Bound Driving Lane, MSU Station 42

Fig. 21A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



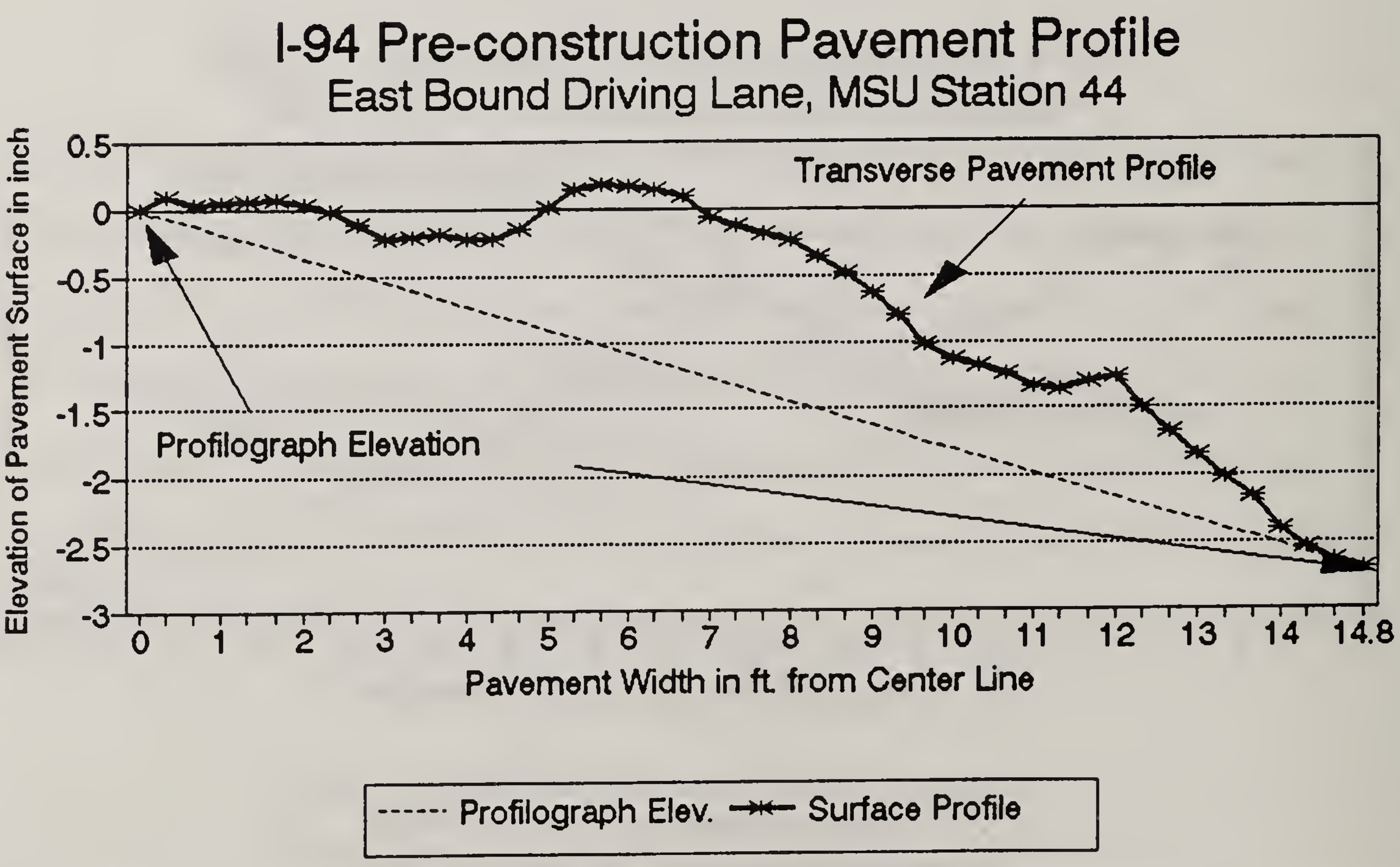
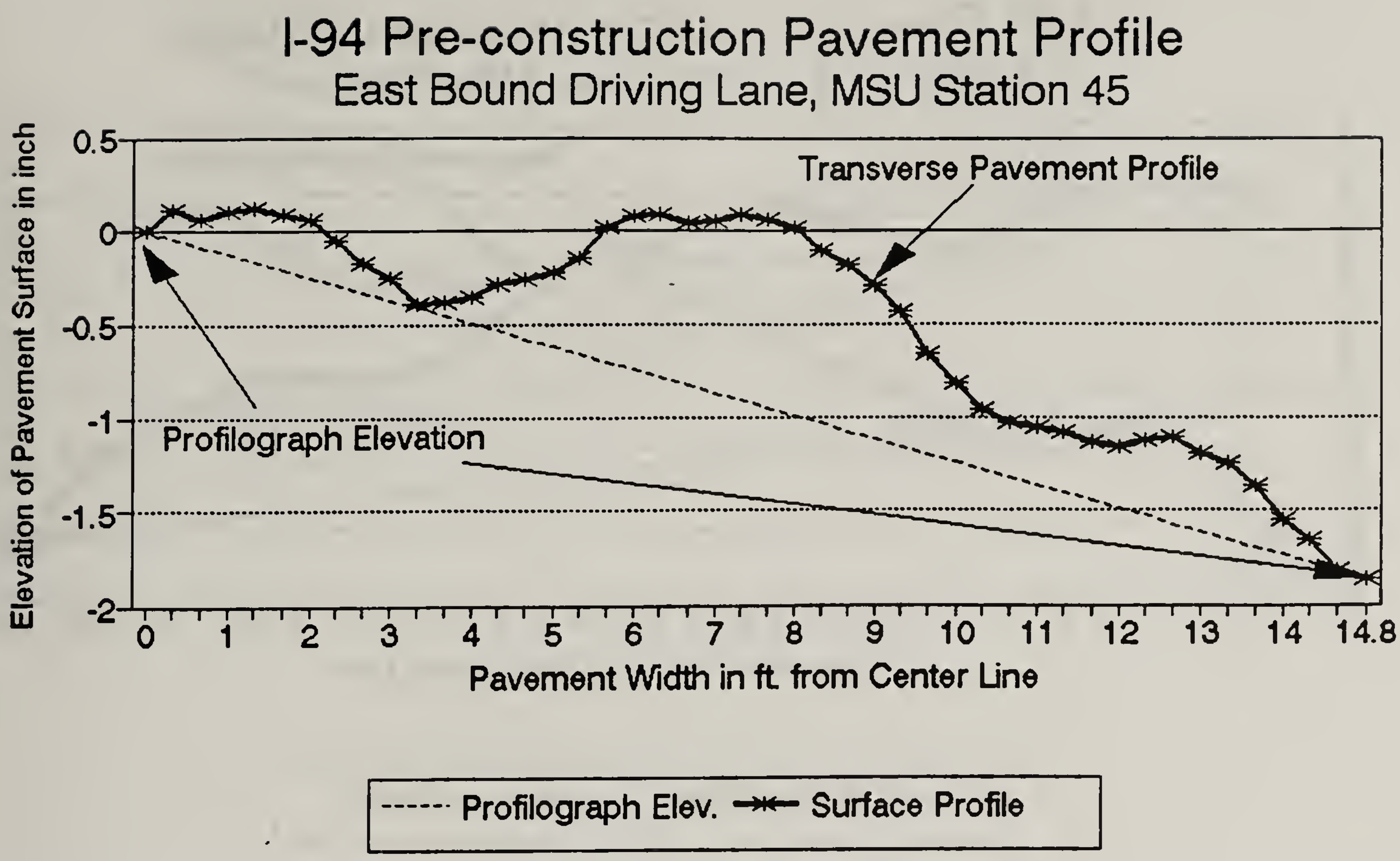


Fig. 22A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



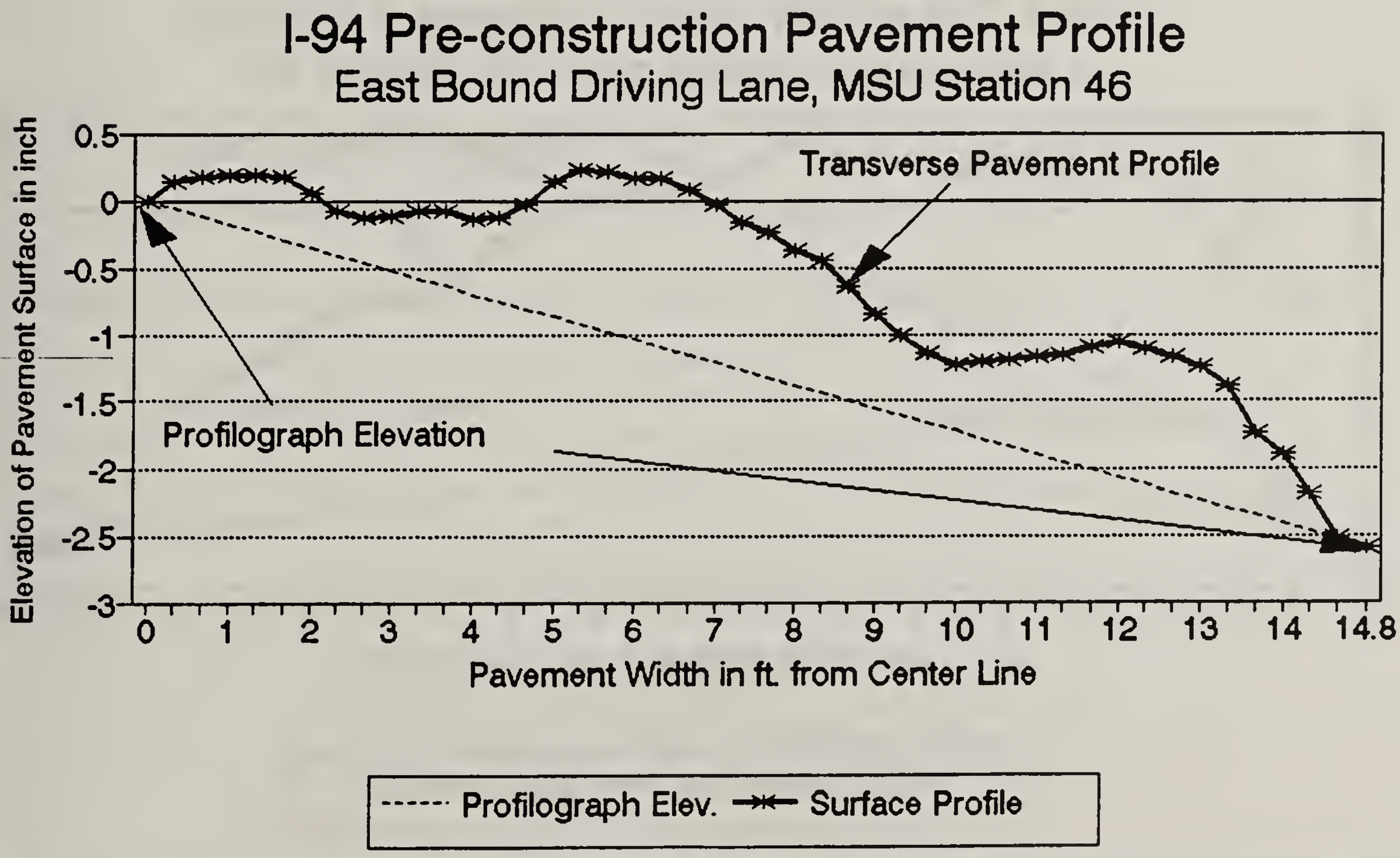
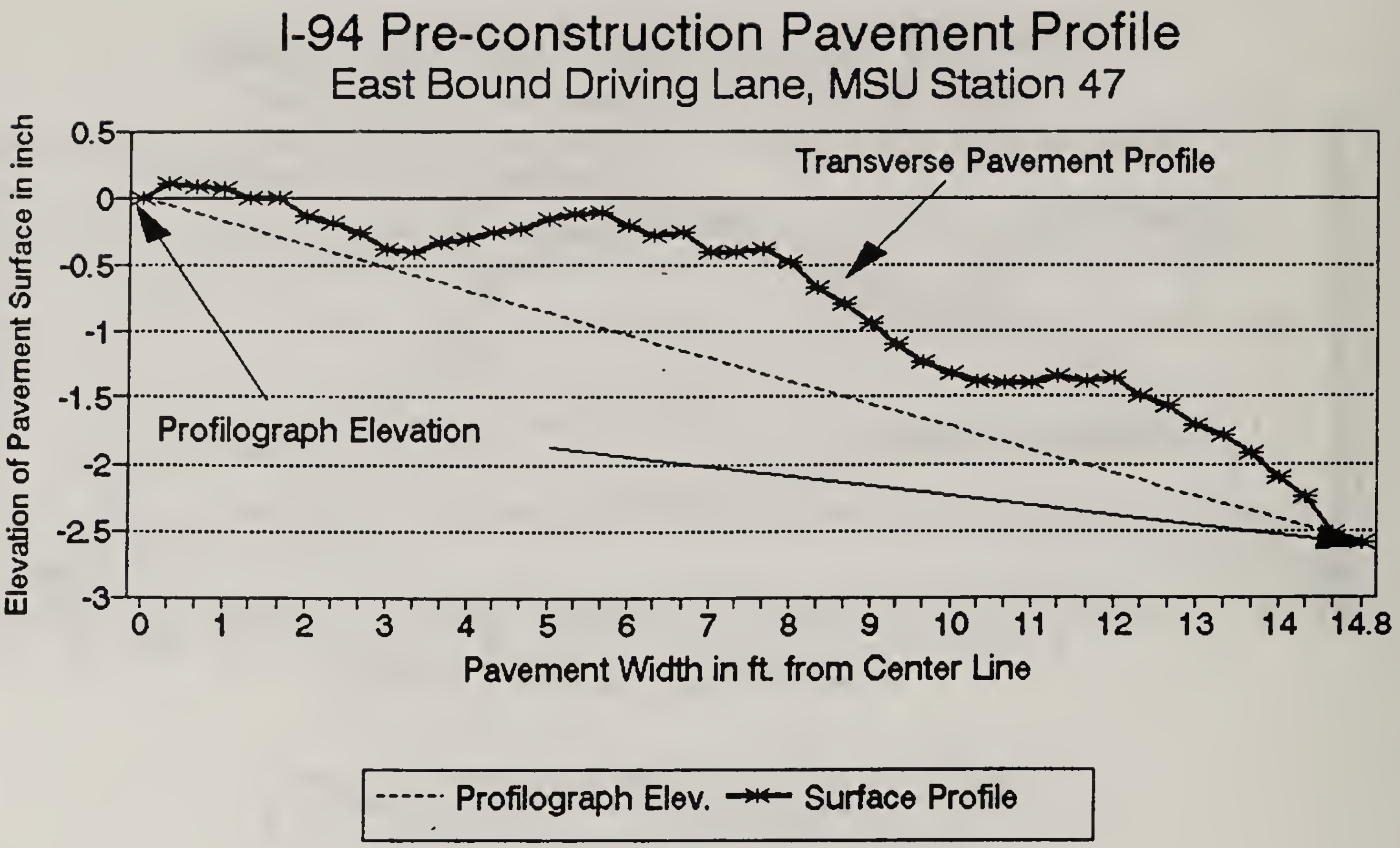


Fig. 23A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



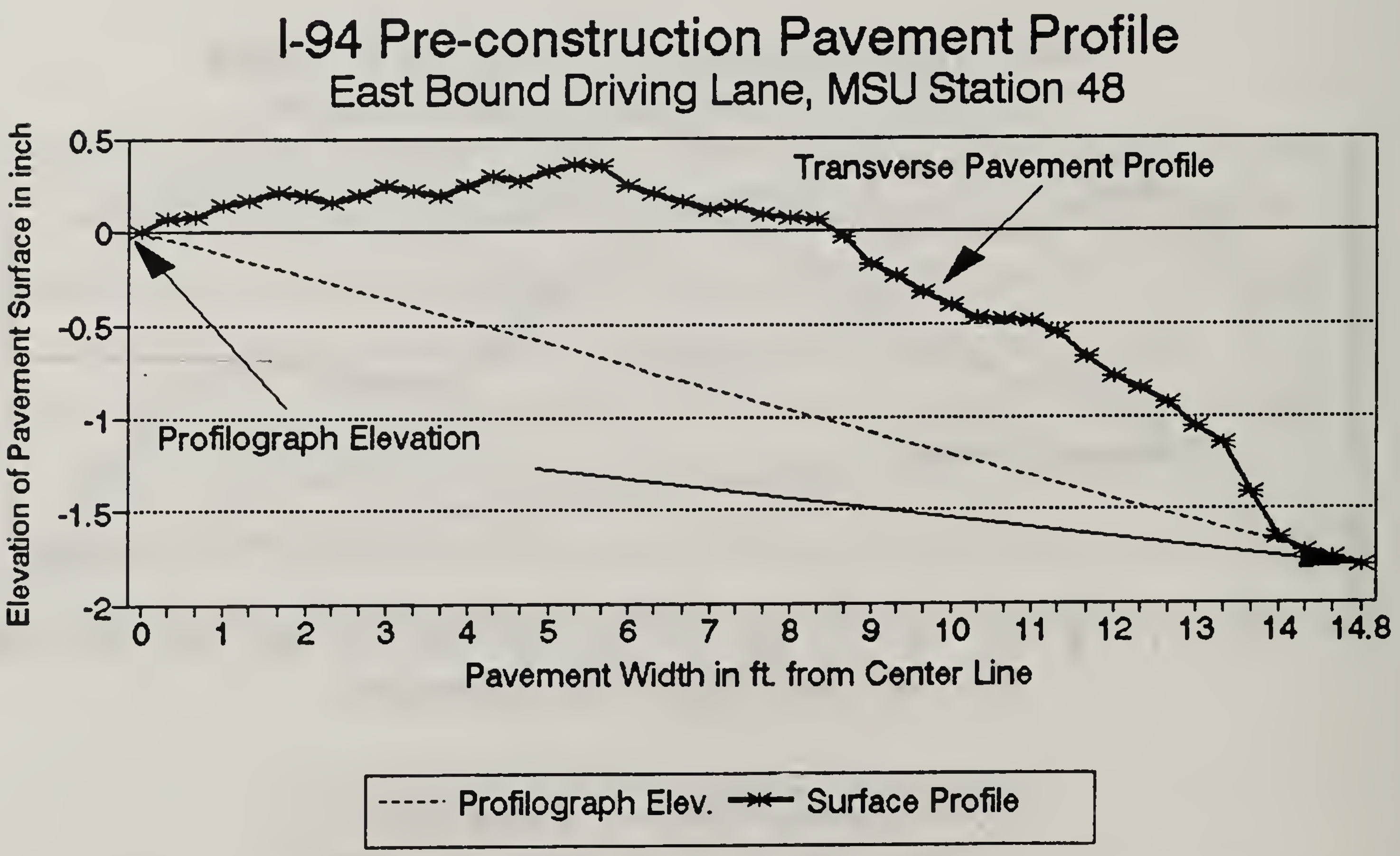
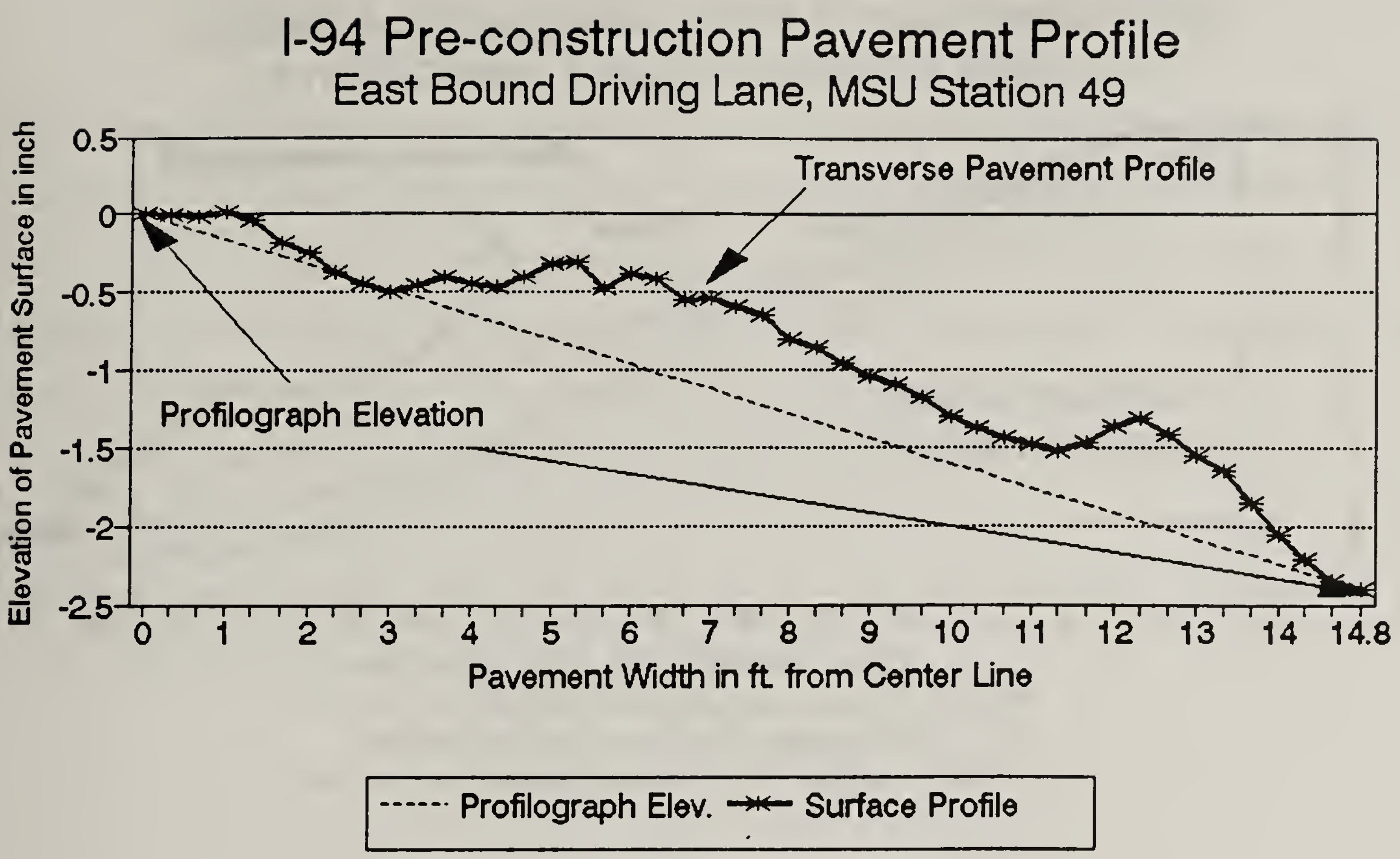


Fig. 24A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



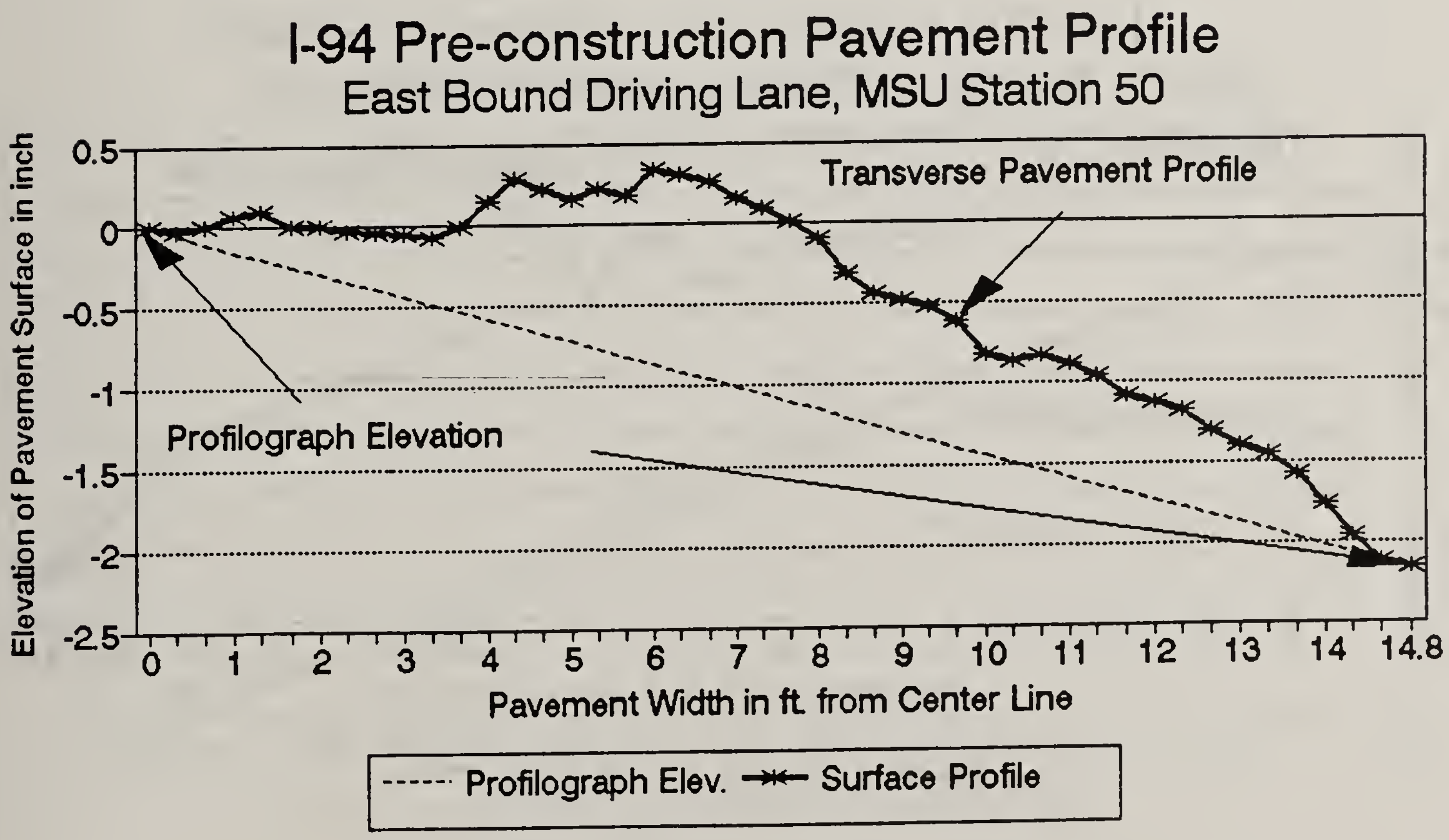
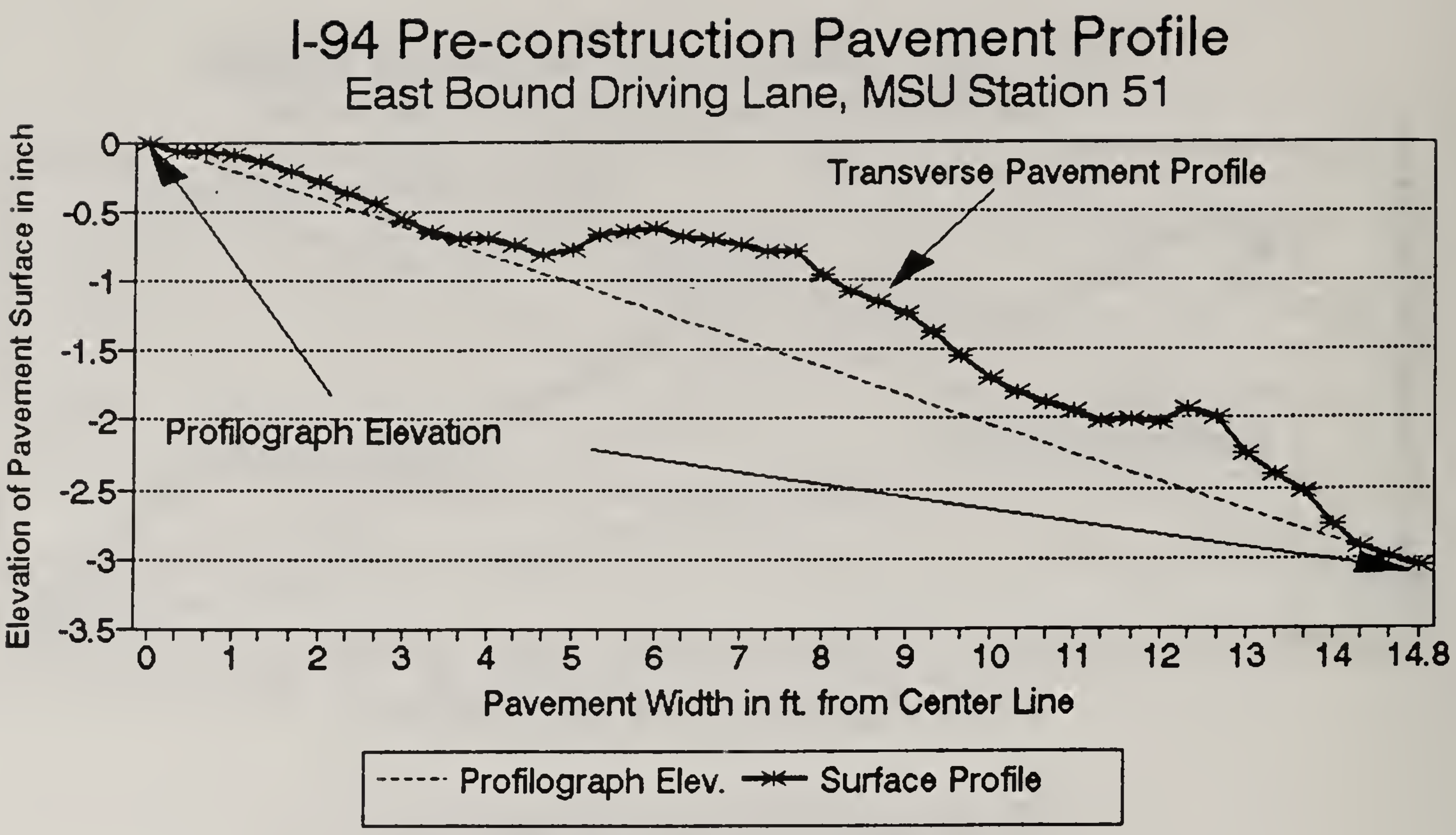


Fig. 25A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



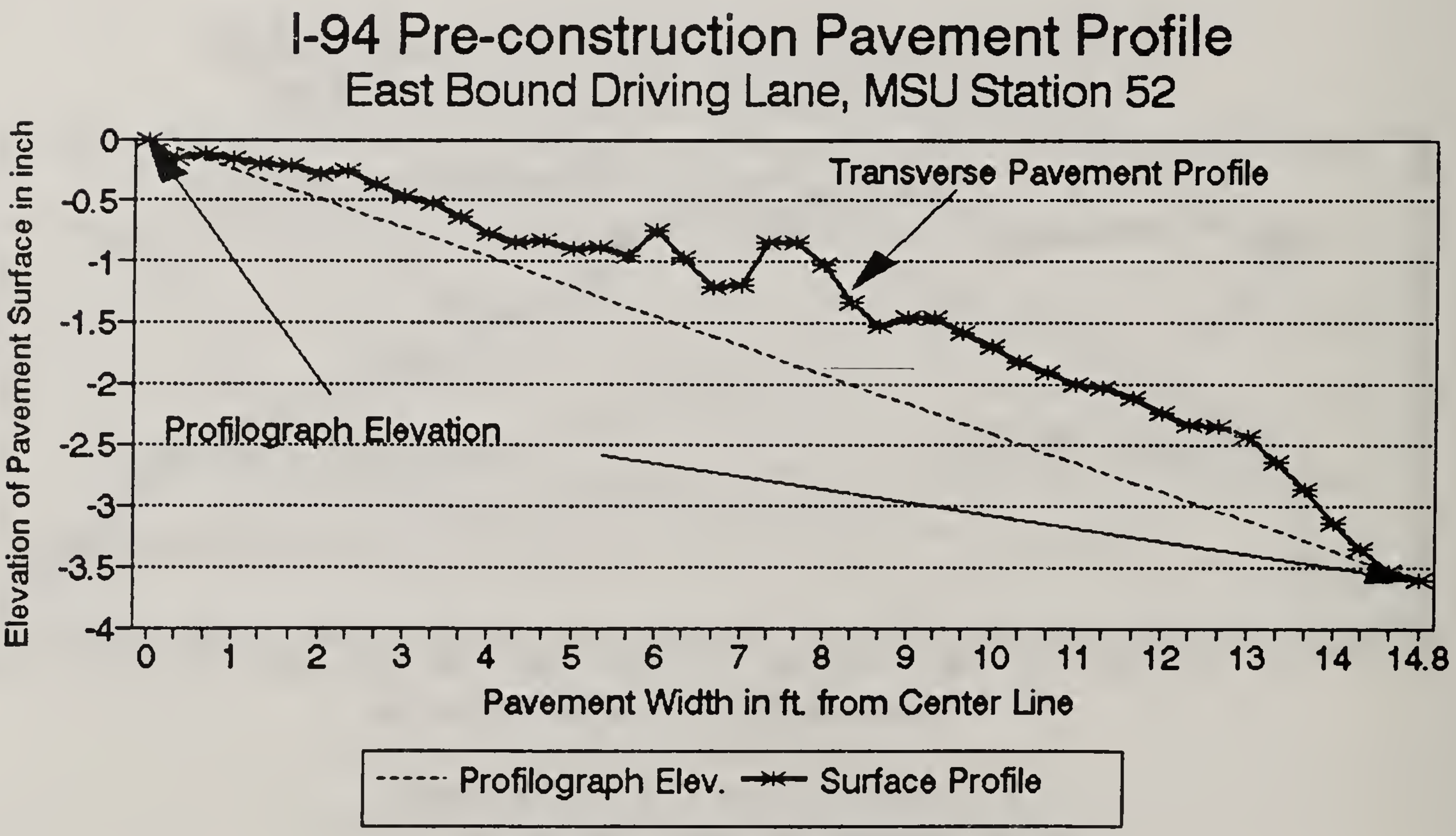
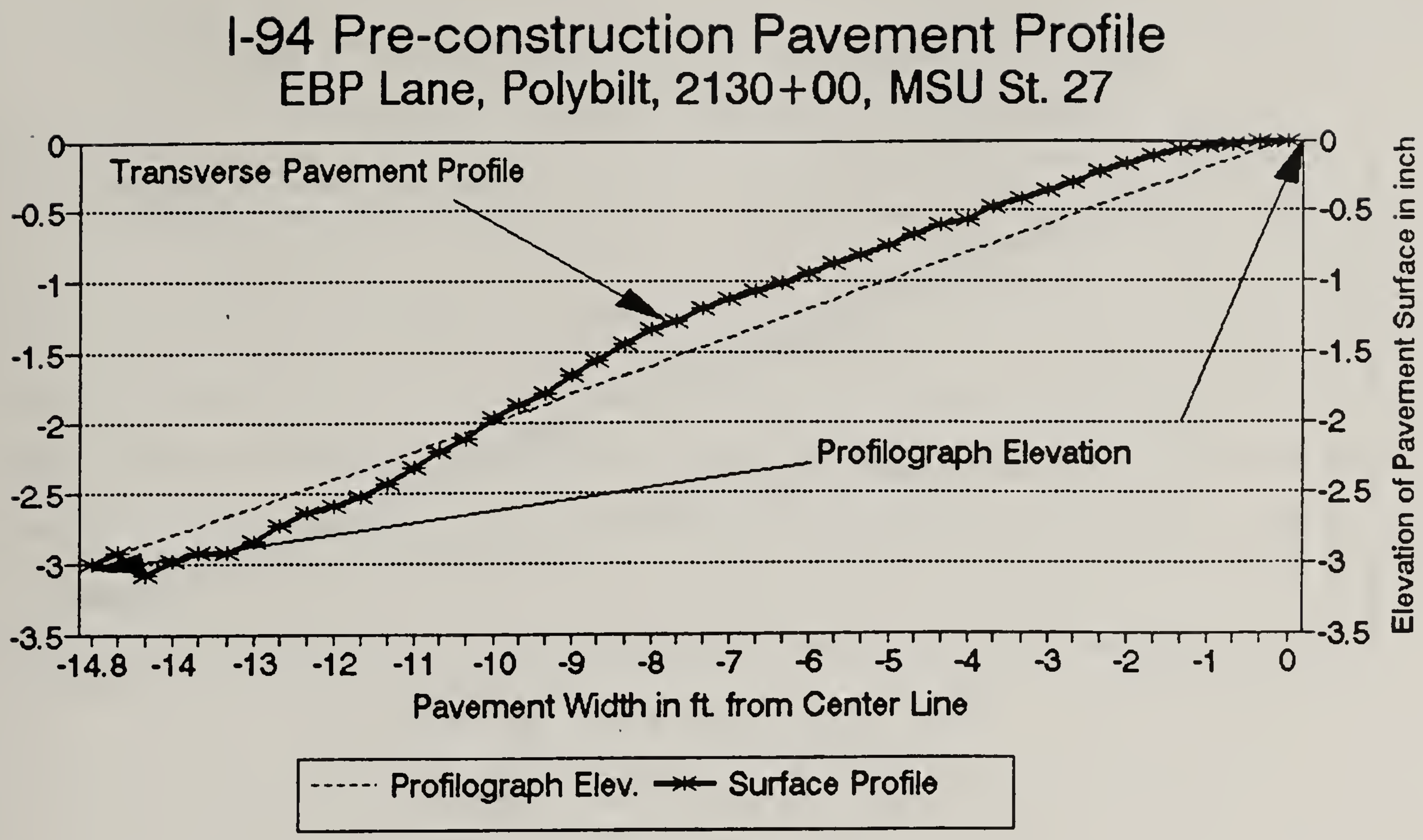


Fig. 26A. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section

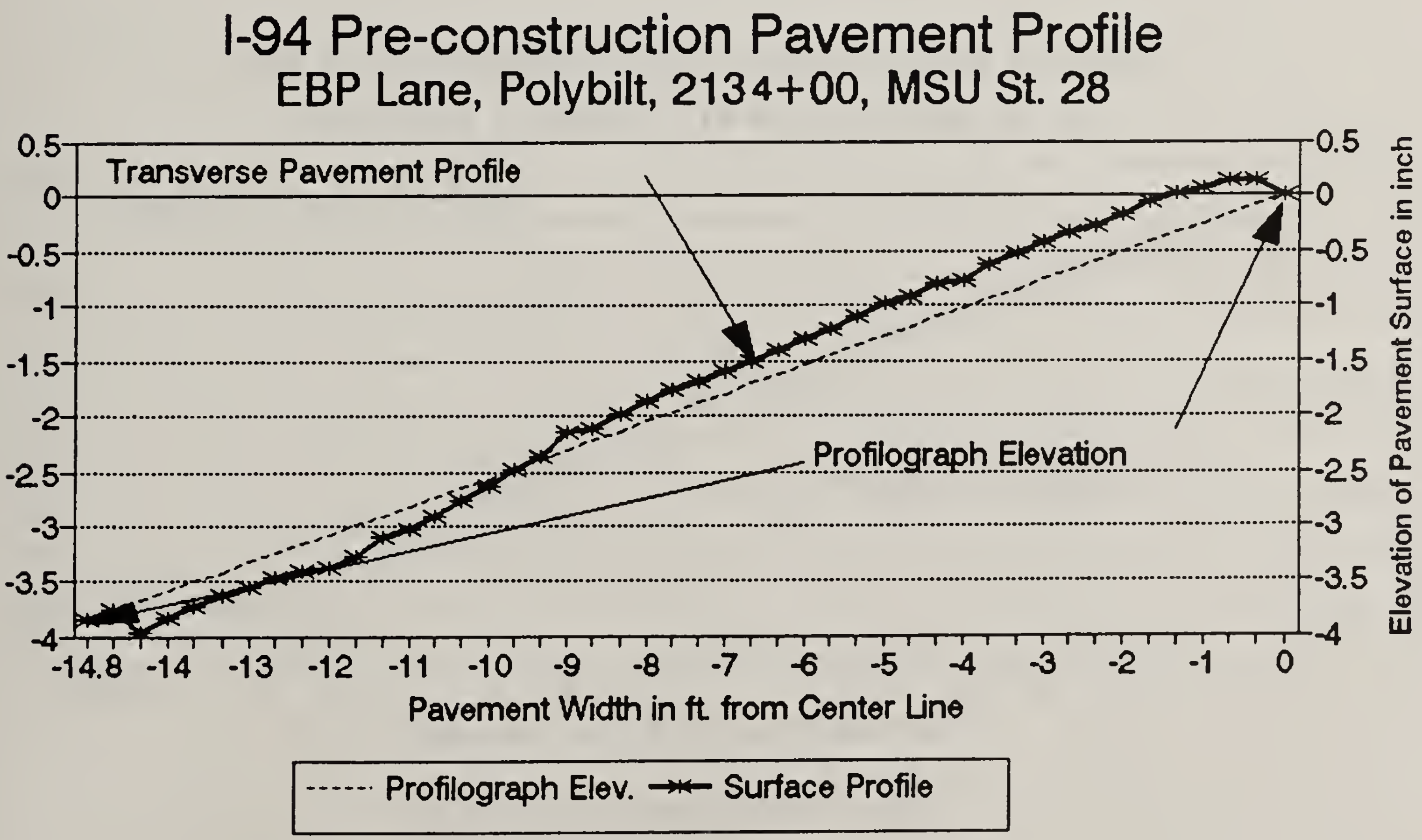
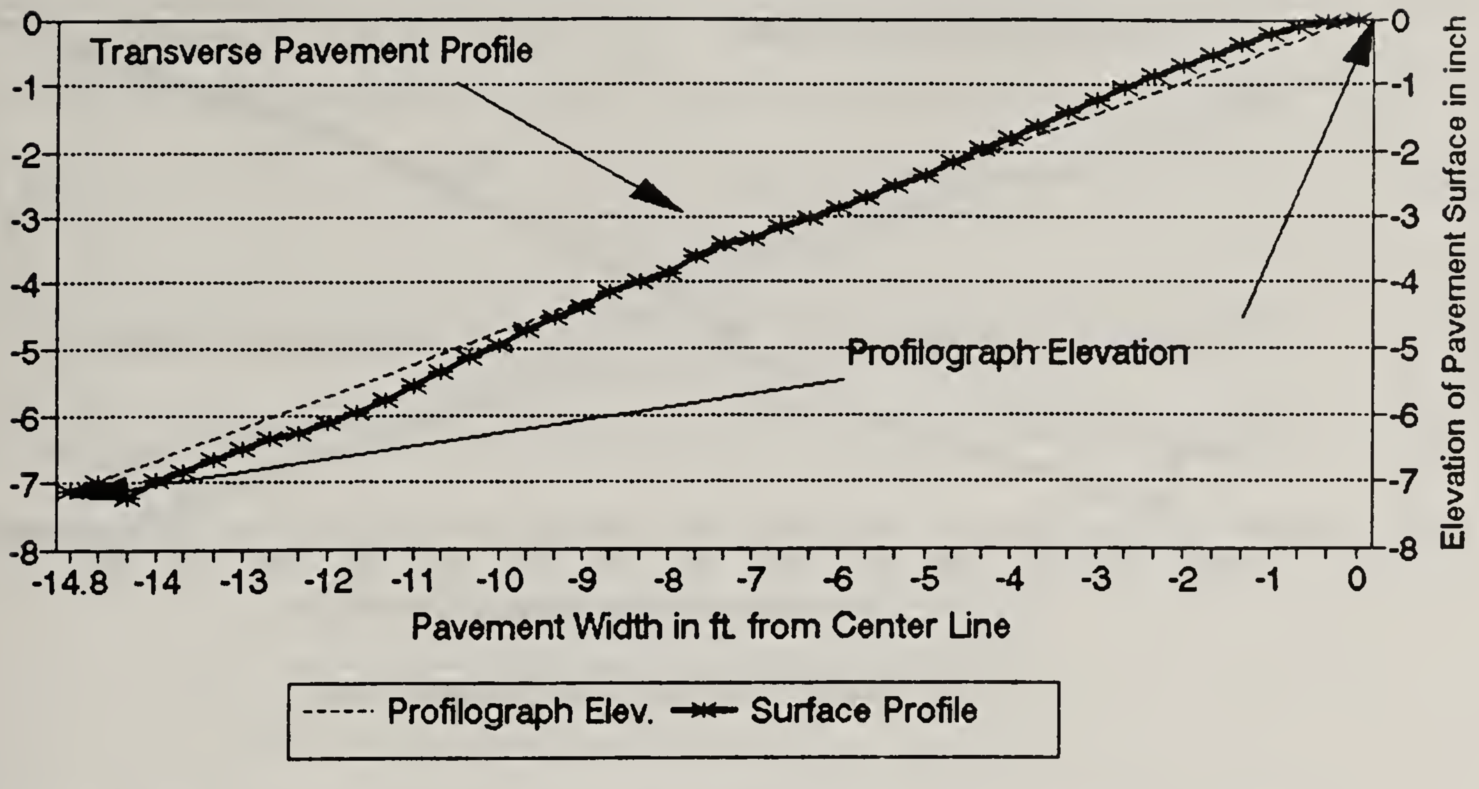


Figure 14B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin

I-94 Pre-construction Pavement Profile
EBP Lane, Polybilt, 2138+00, MSU St. 29



Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section

I-94 Pre-construction Pavement Profile
EBP Lane, Polybilt, 214 4+00, MSU St. 30

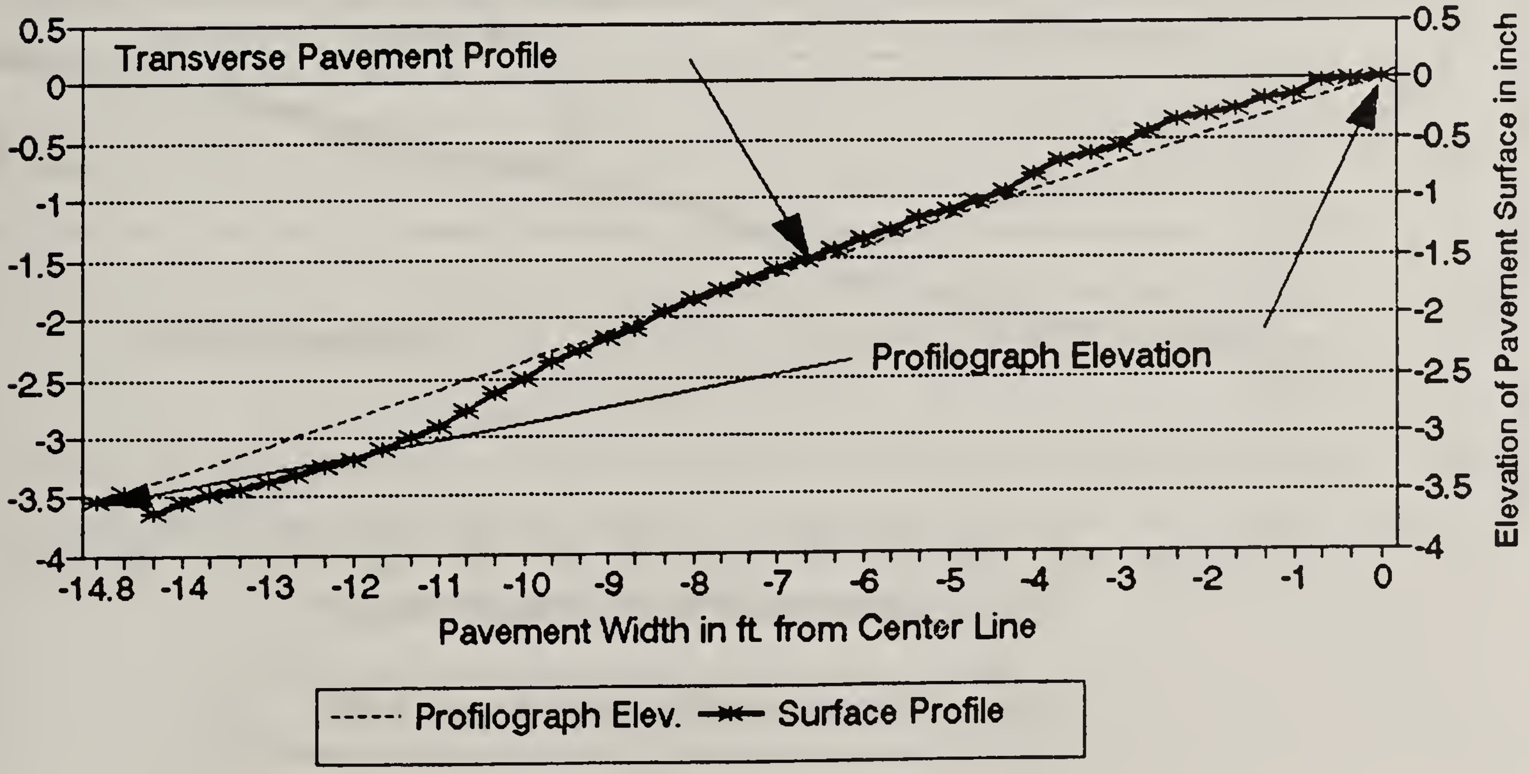
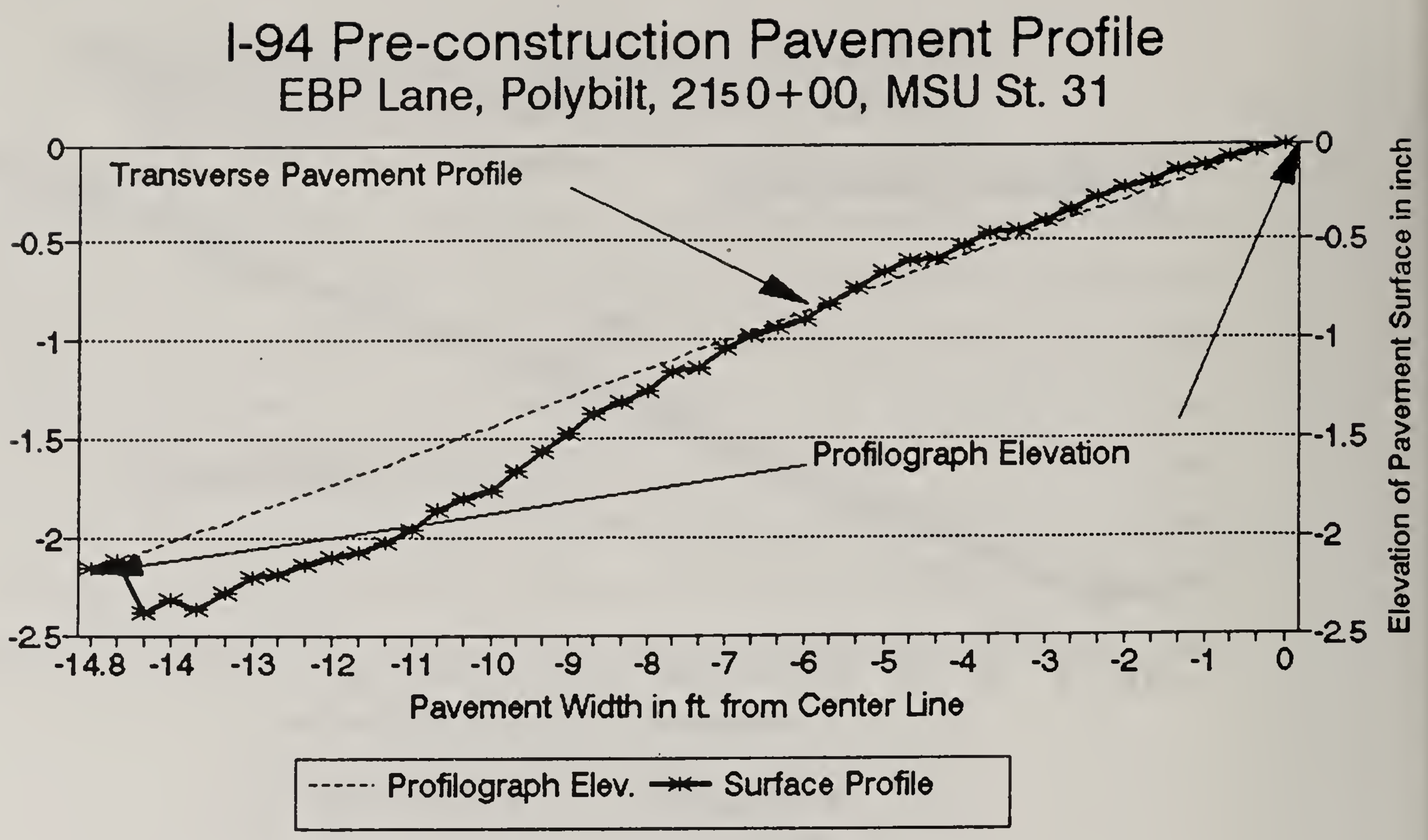


Figure 15B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section

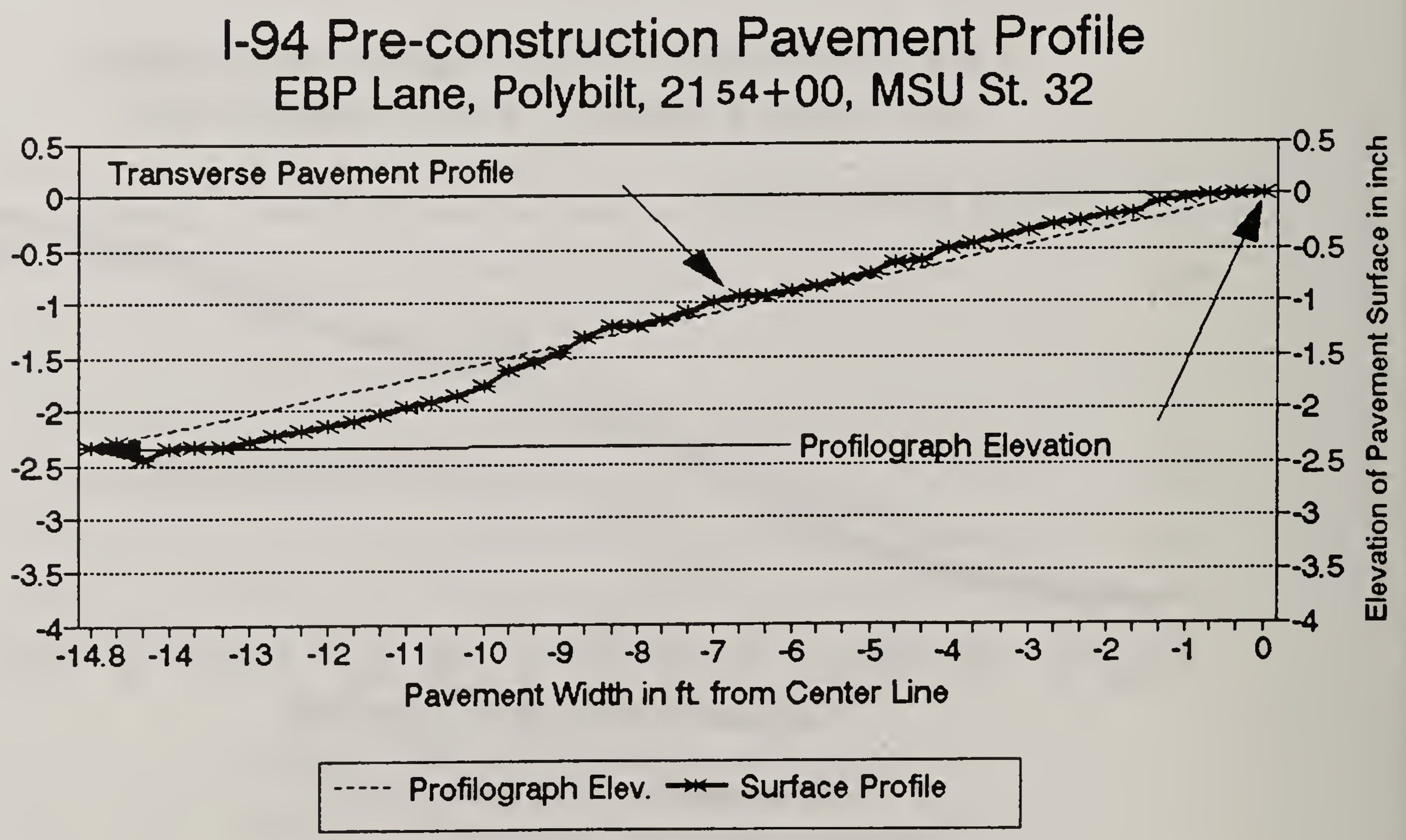
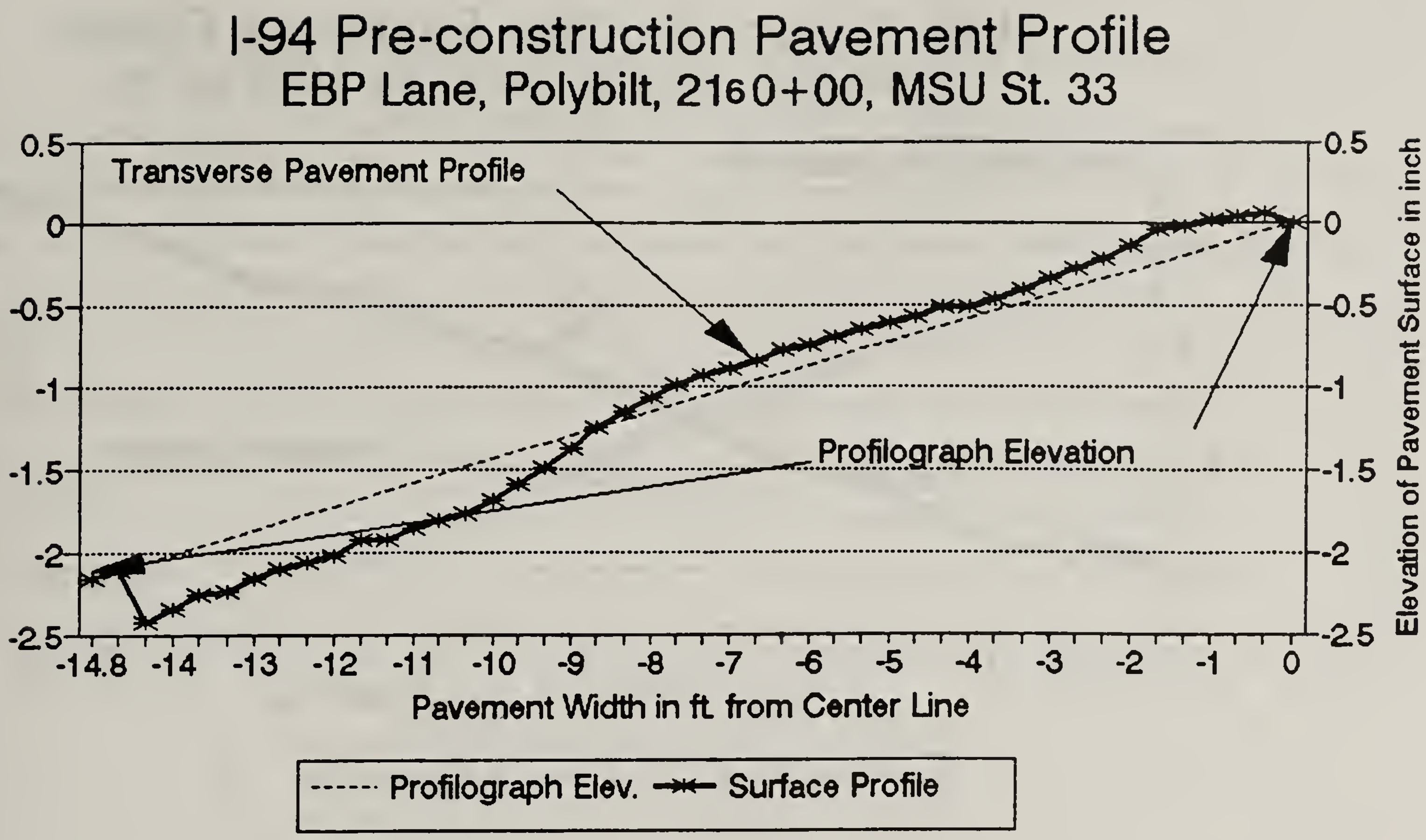


Figure 16B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section

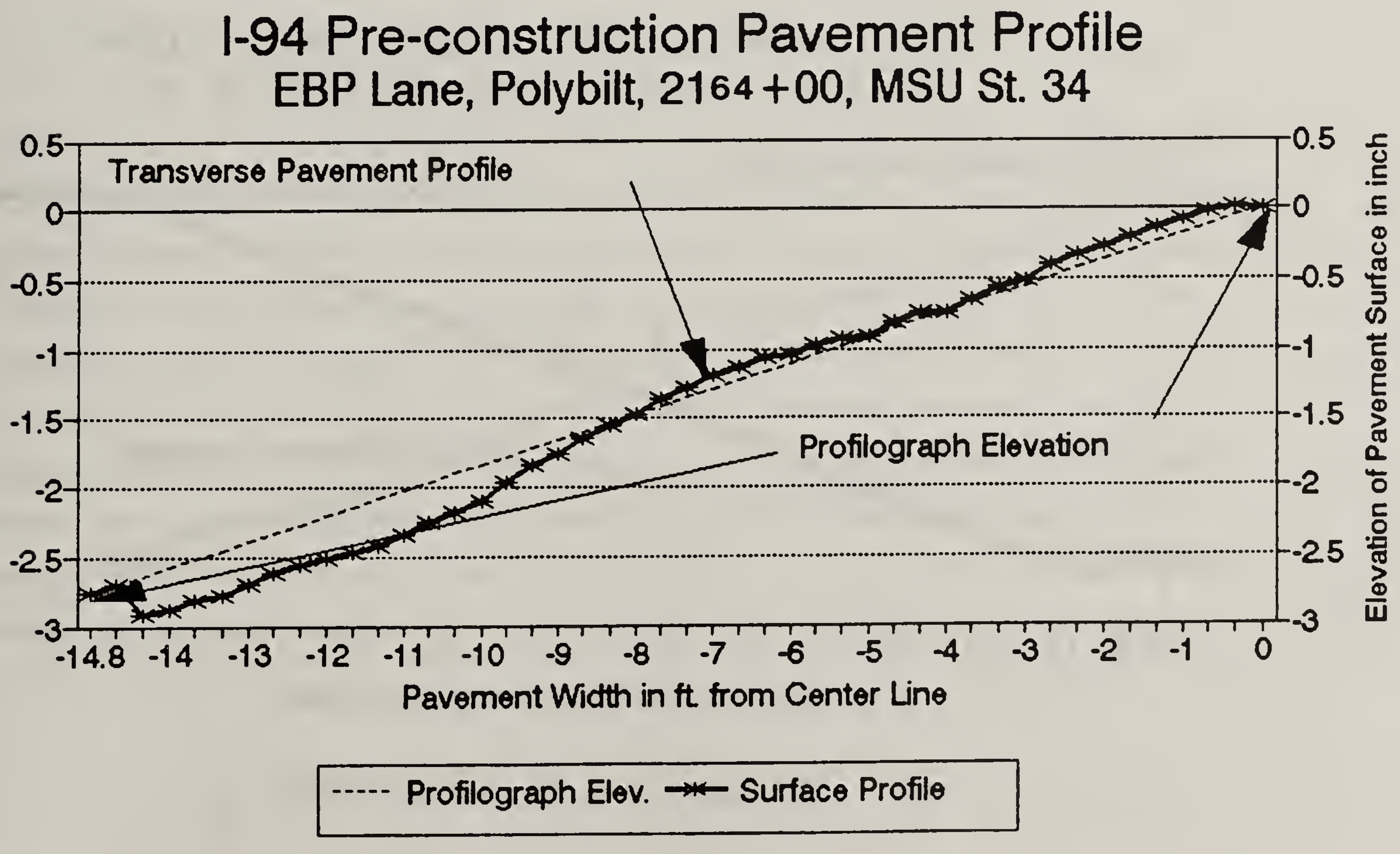
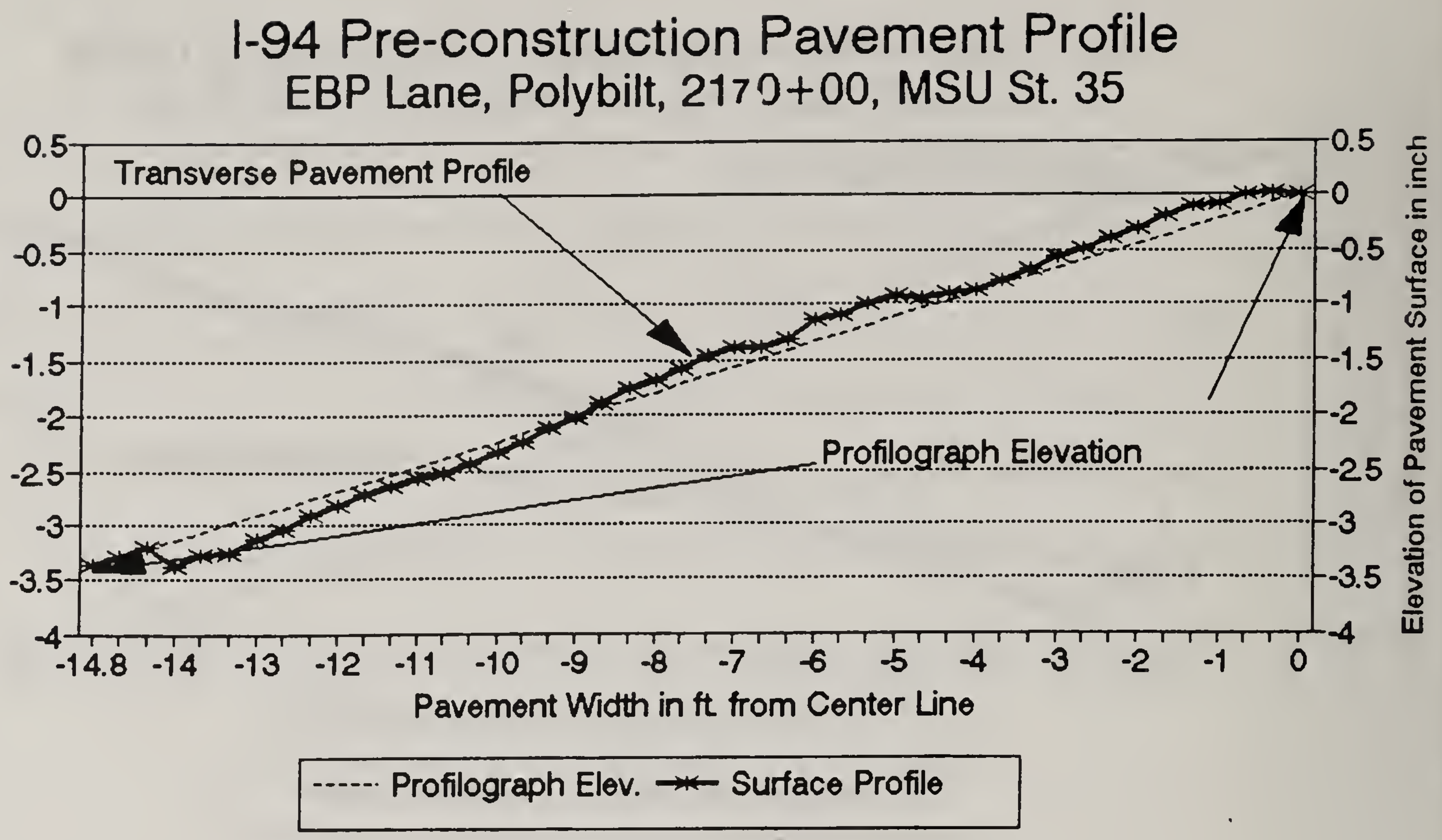
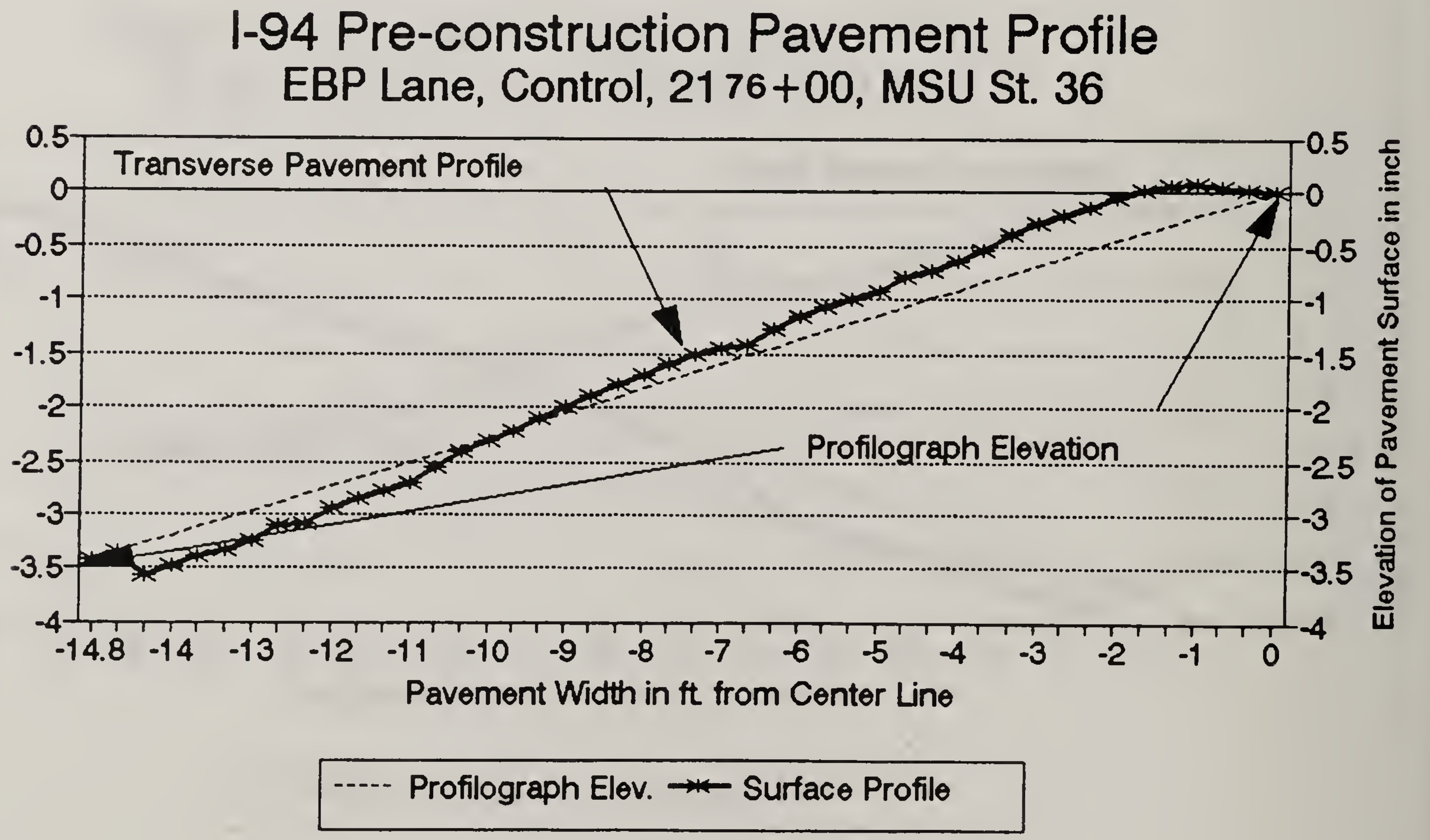


Fig. 17B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Pre-construction Pavement Profile

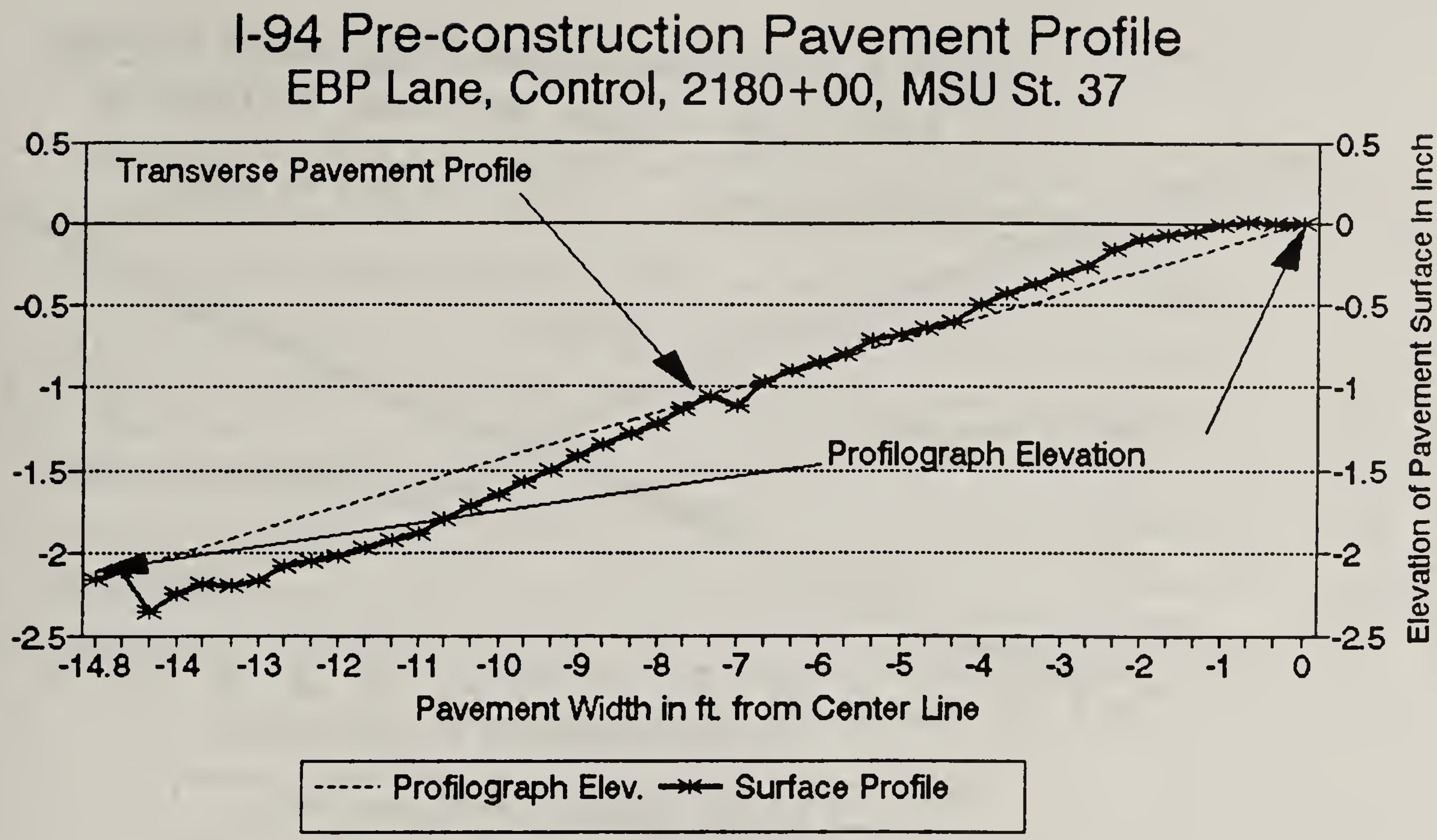
EBP Lane, Polybilt, 2170+00, MSU St. 35

Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section


I-94 Pre-construction Pavement Profile

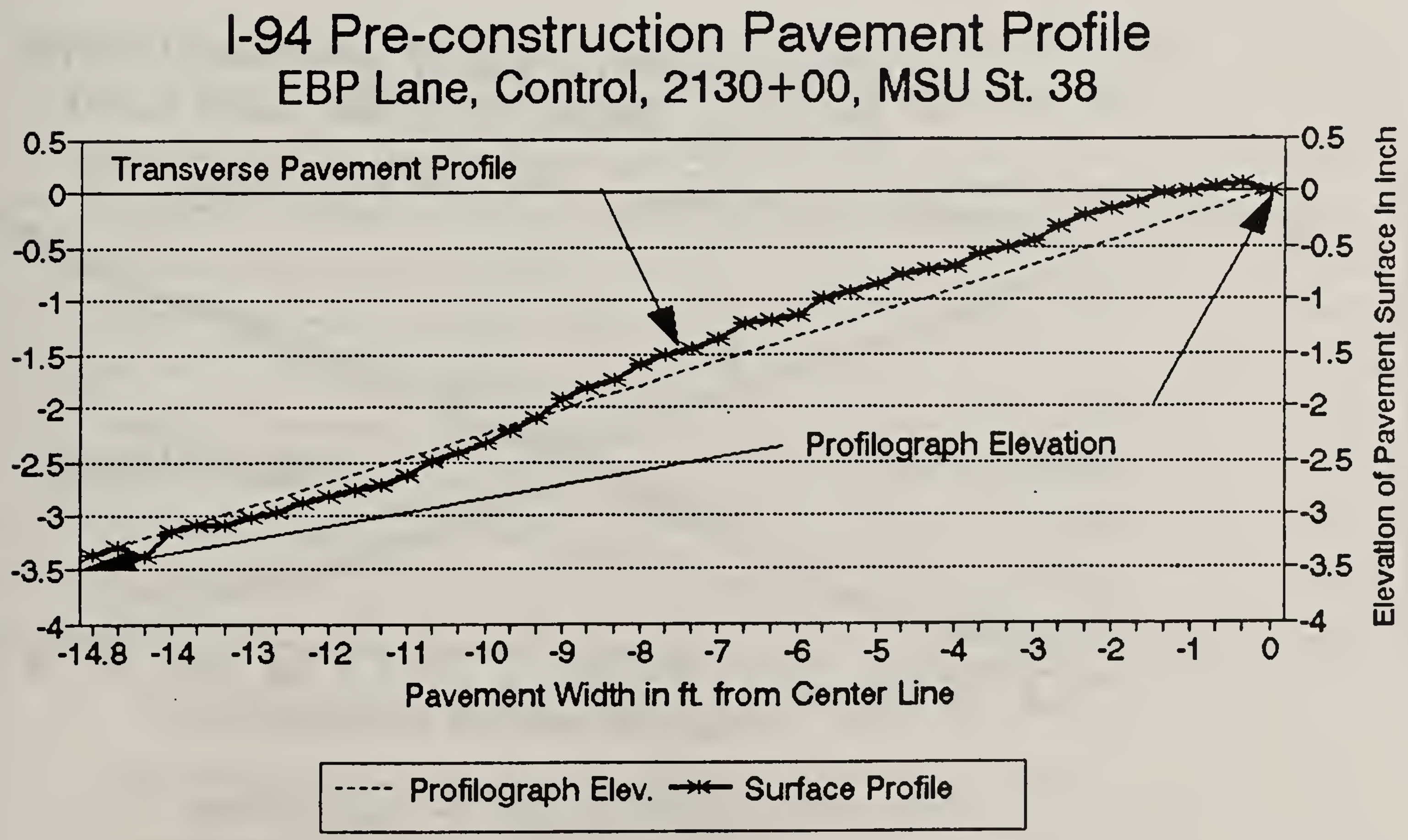
EBP Lane, Control, 2176+00, MSU St. 36

Fig. 18B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



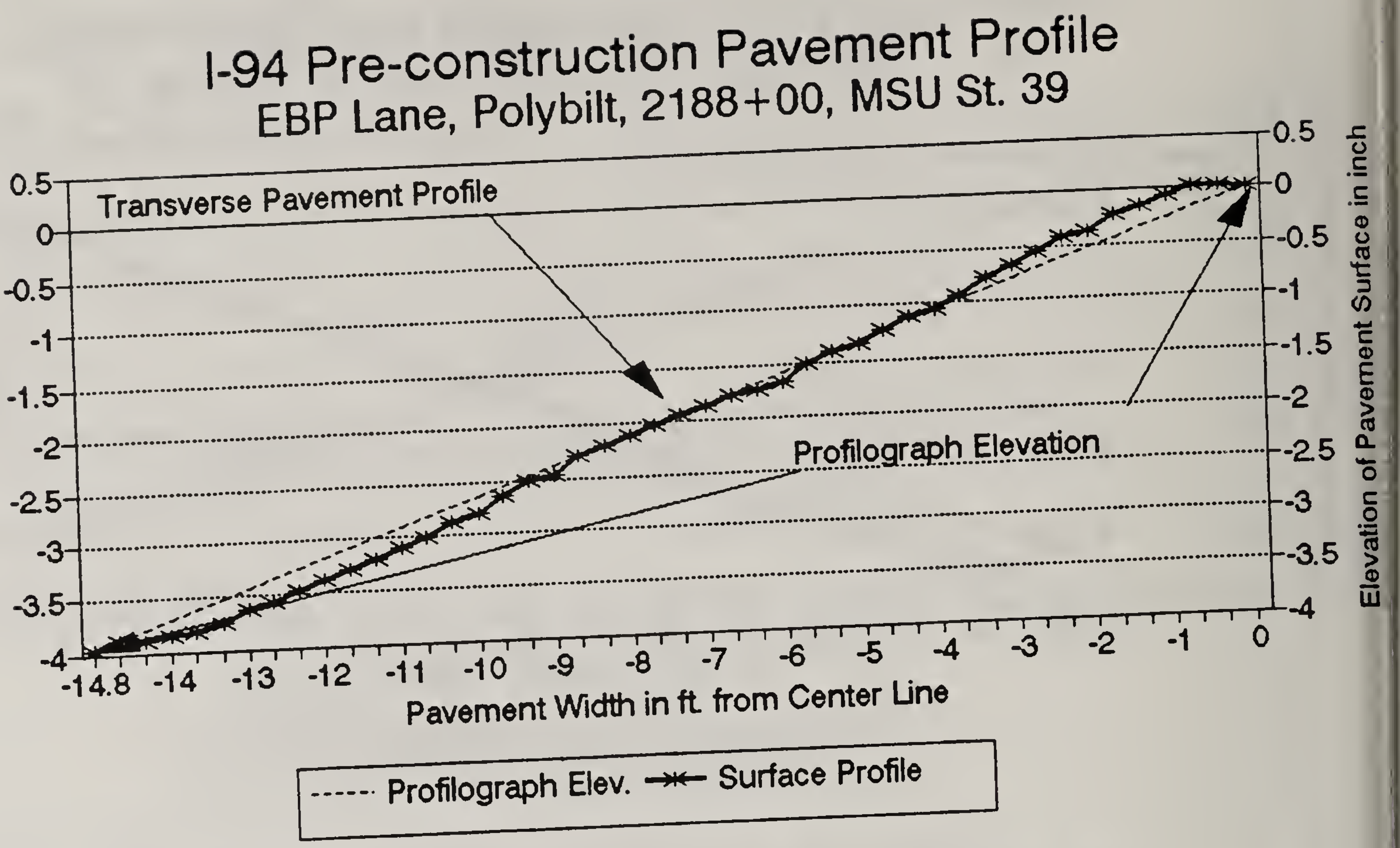
I-94 Pre-construction Pavement Profile
EBP Lane, Control, 2180+00, MSU St. 37

Note: East Bound Passing (EBP) Lane, Control Section - Exxon



I-94 Pre-construction Pavement Profile
EBP Lane, Control, 2130+00, MSU St. 38

Fig.19B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Control Section - Exxon

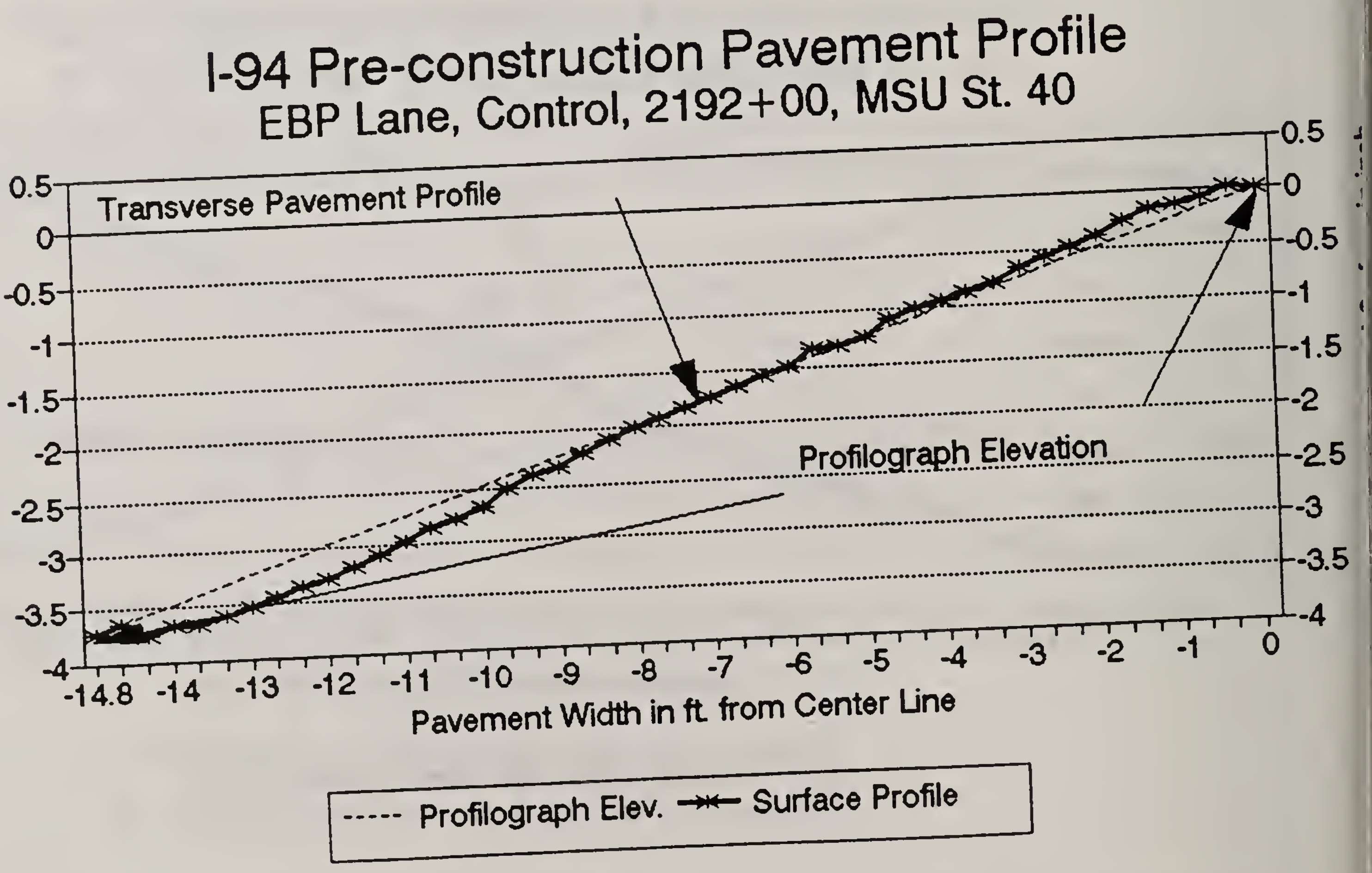
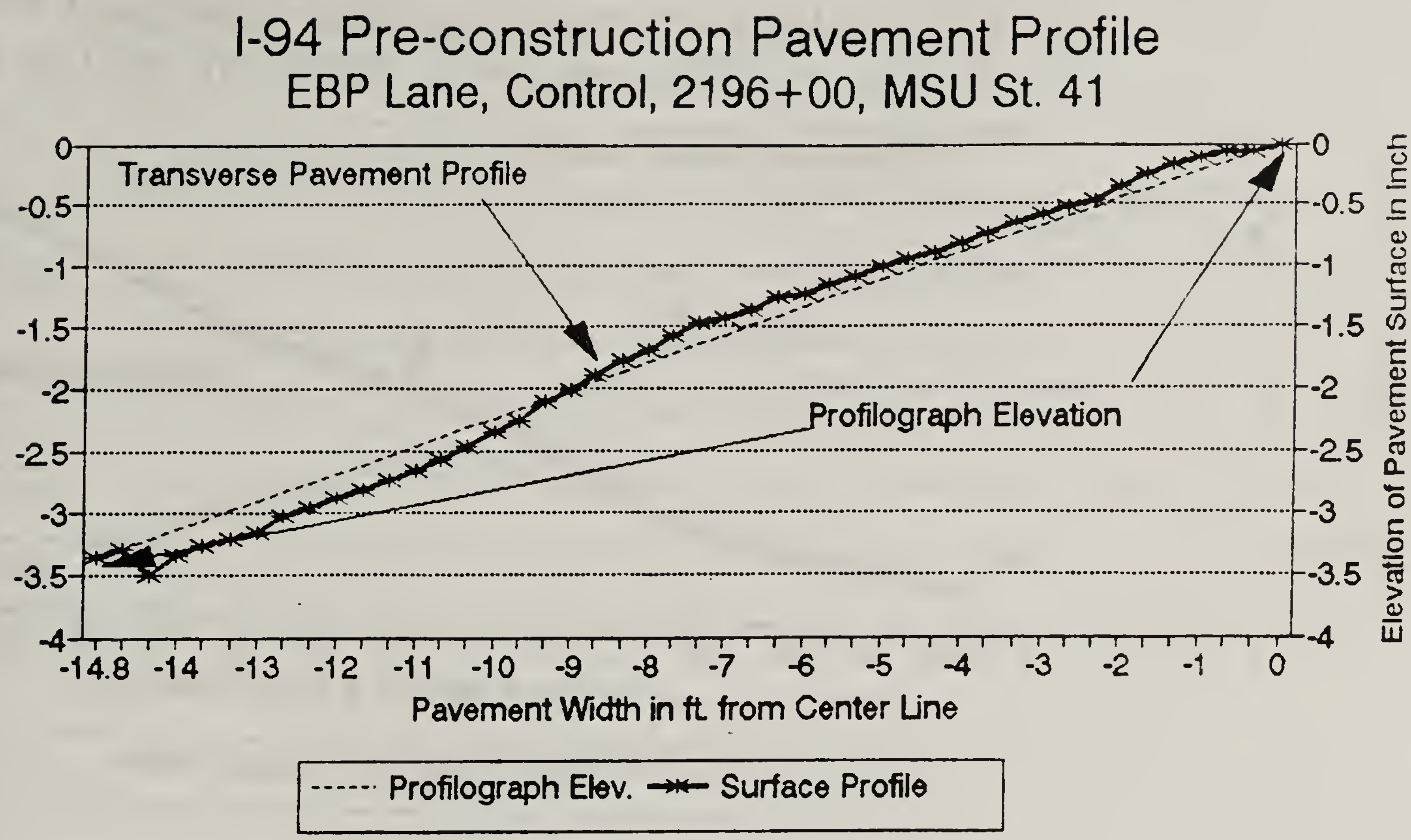


Fig. 20B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Control Section - Exxon

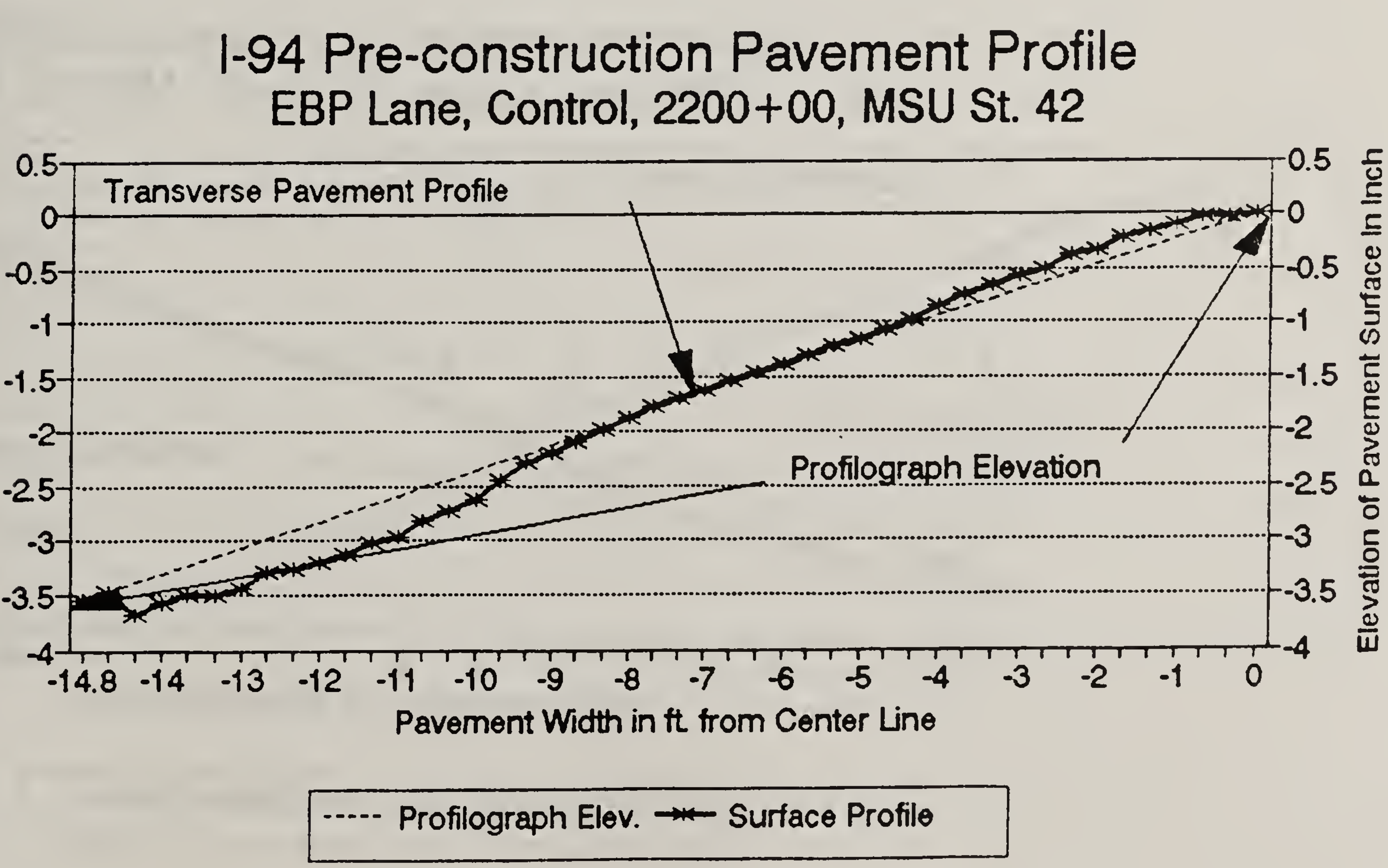
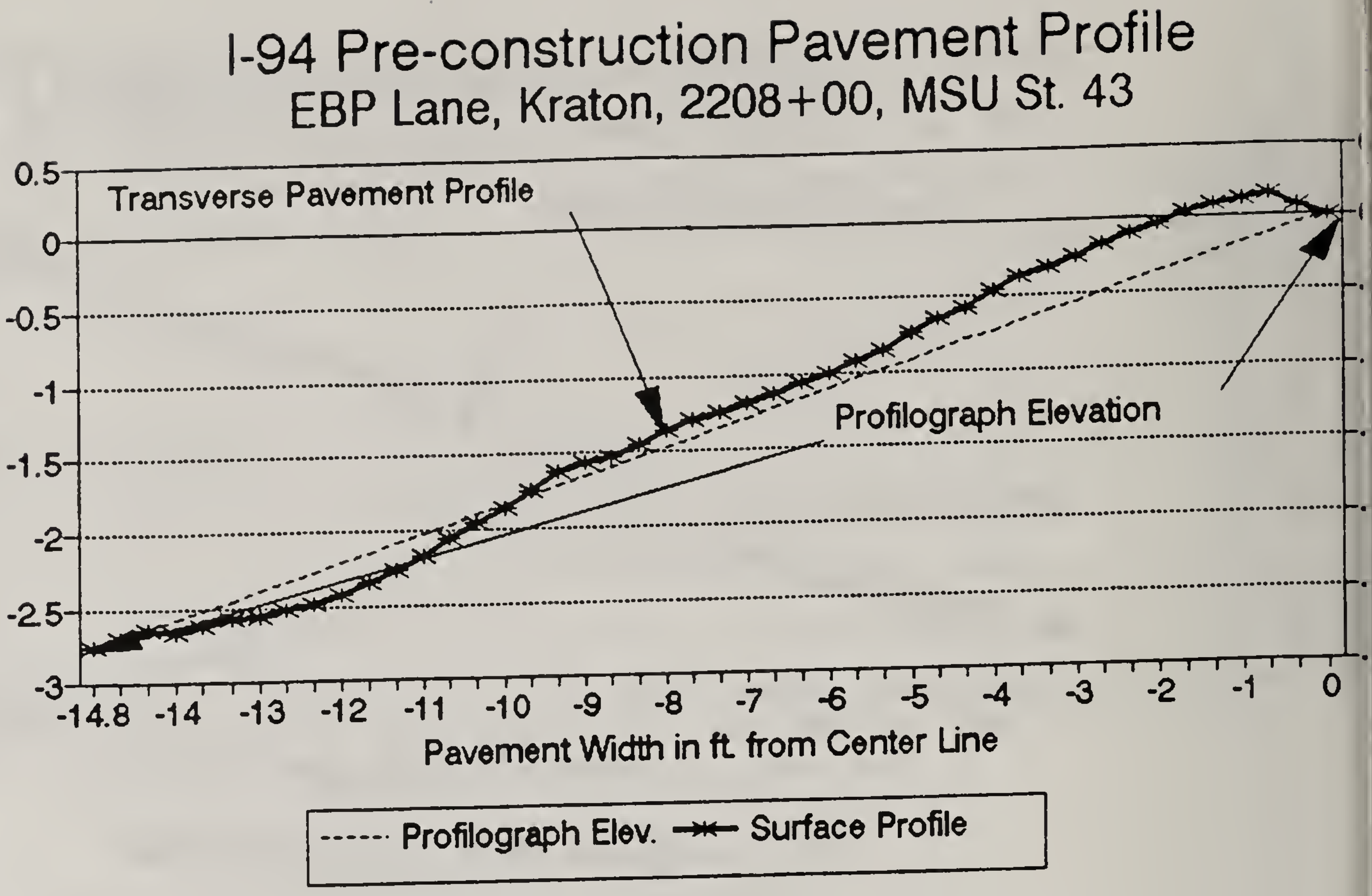


Fig. 21B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Kraton Modified Binder Section

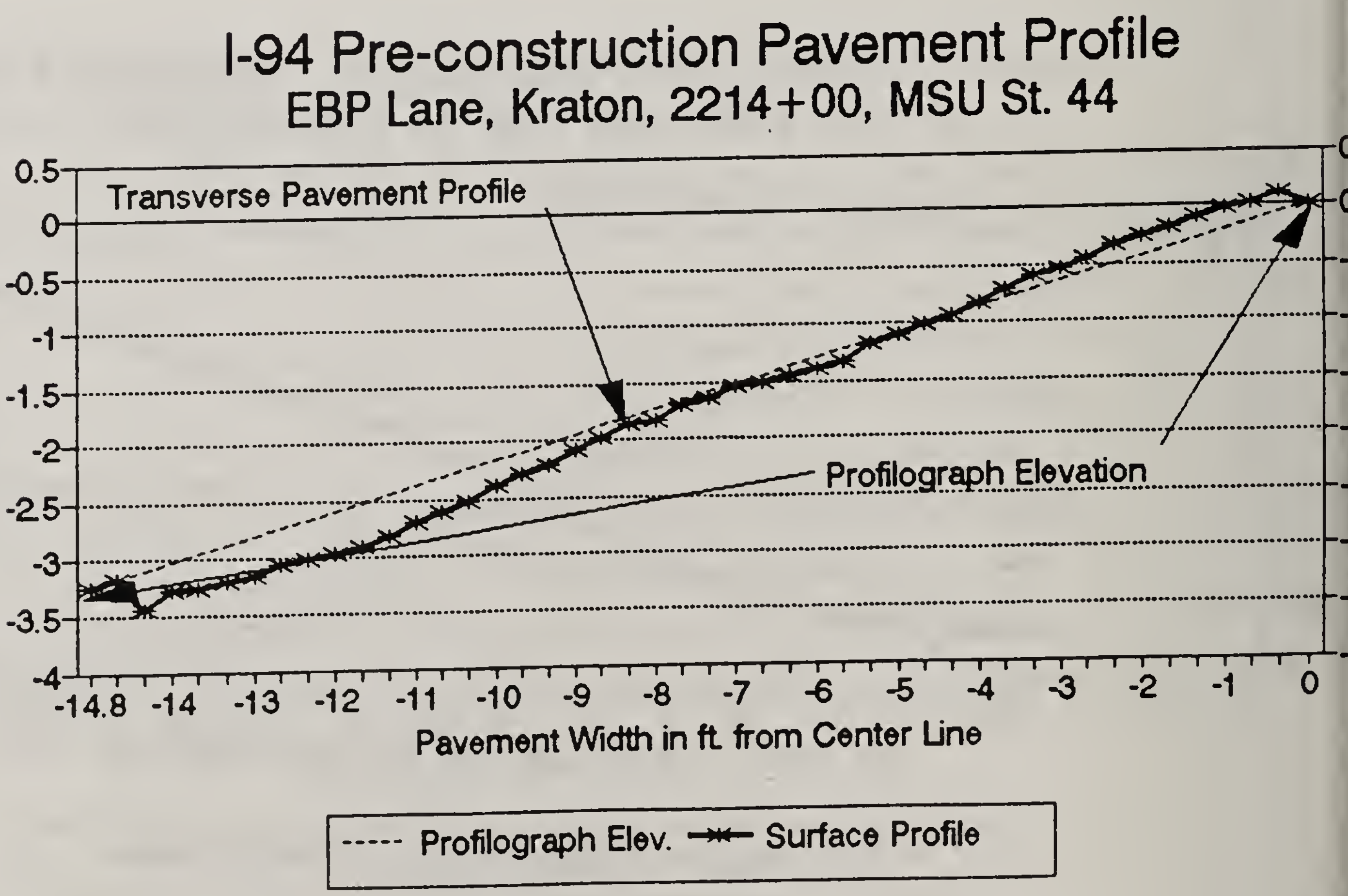
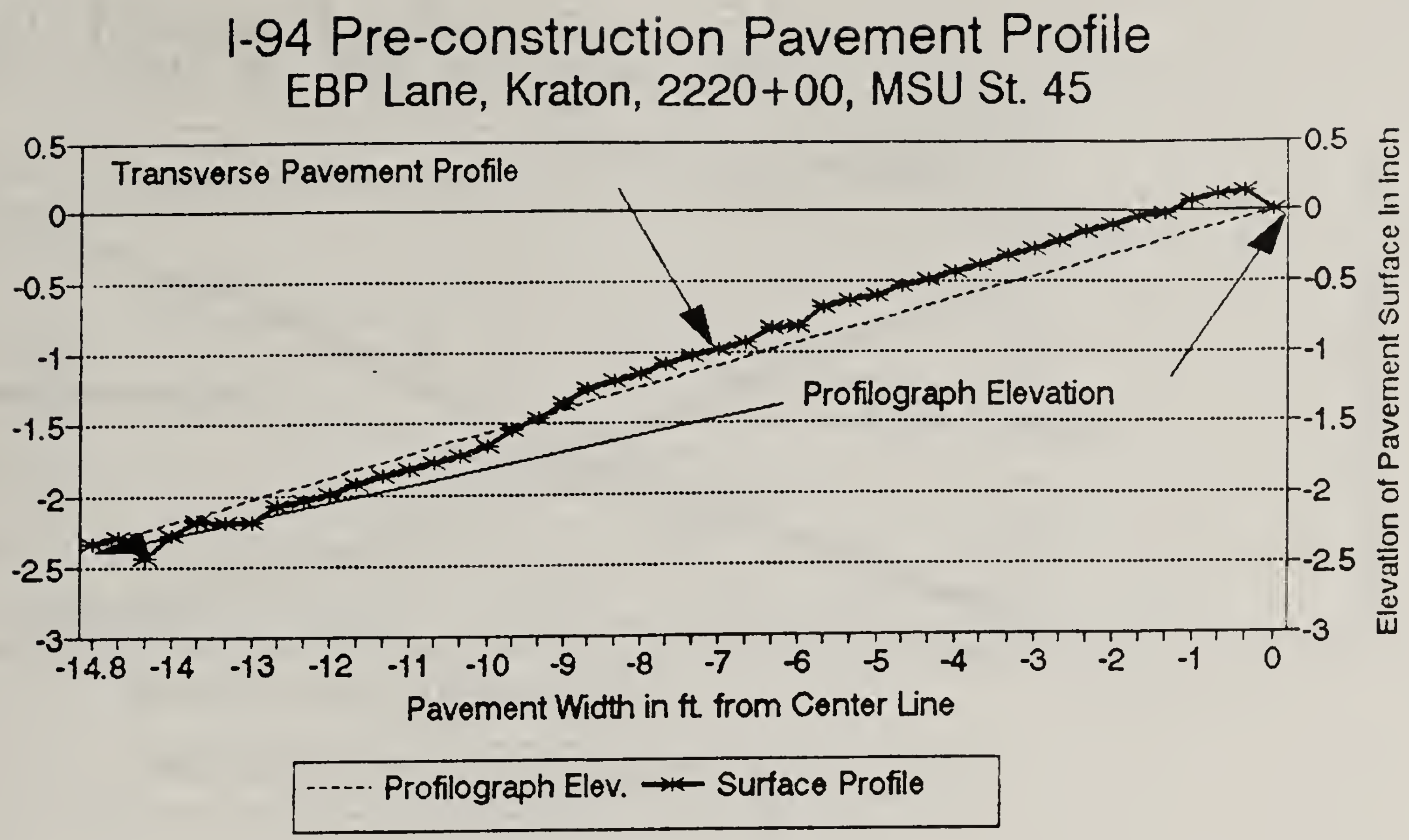


Fig. 22B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Kraton Modified Binder Section

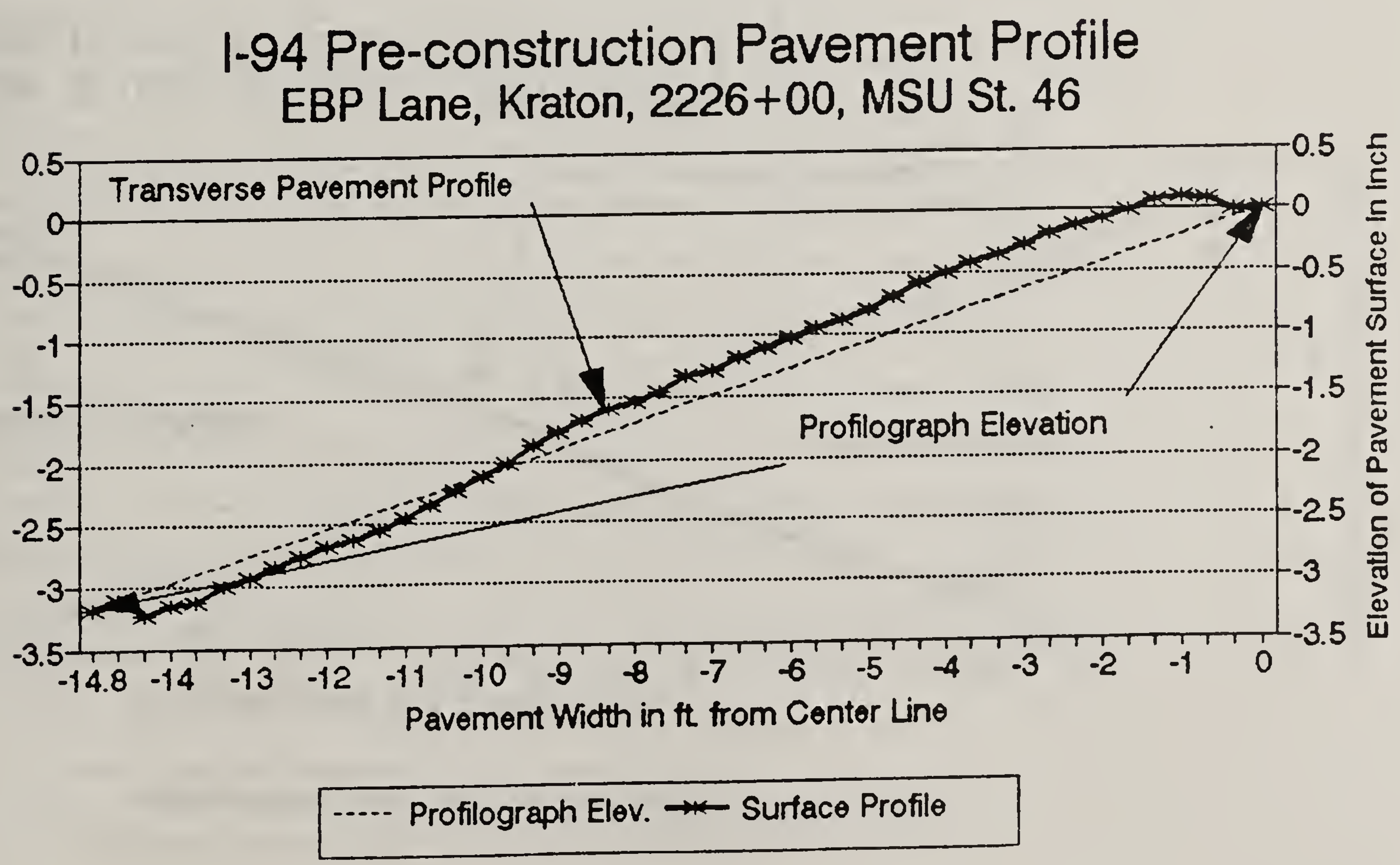
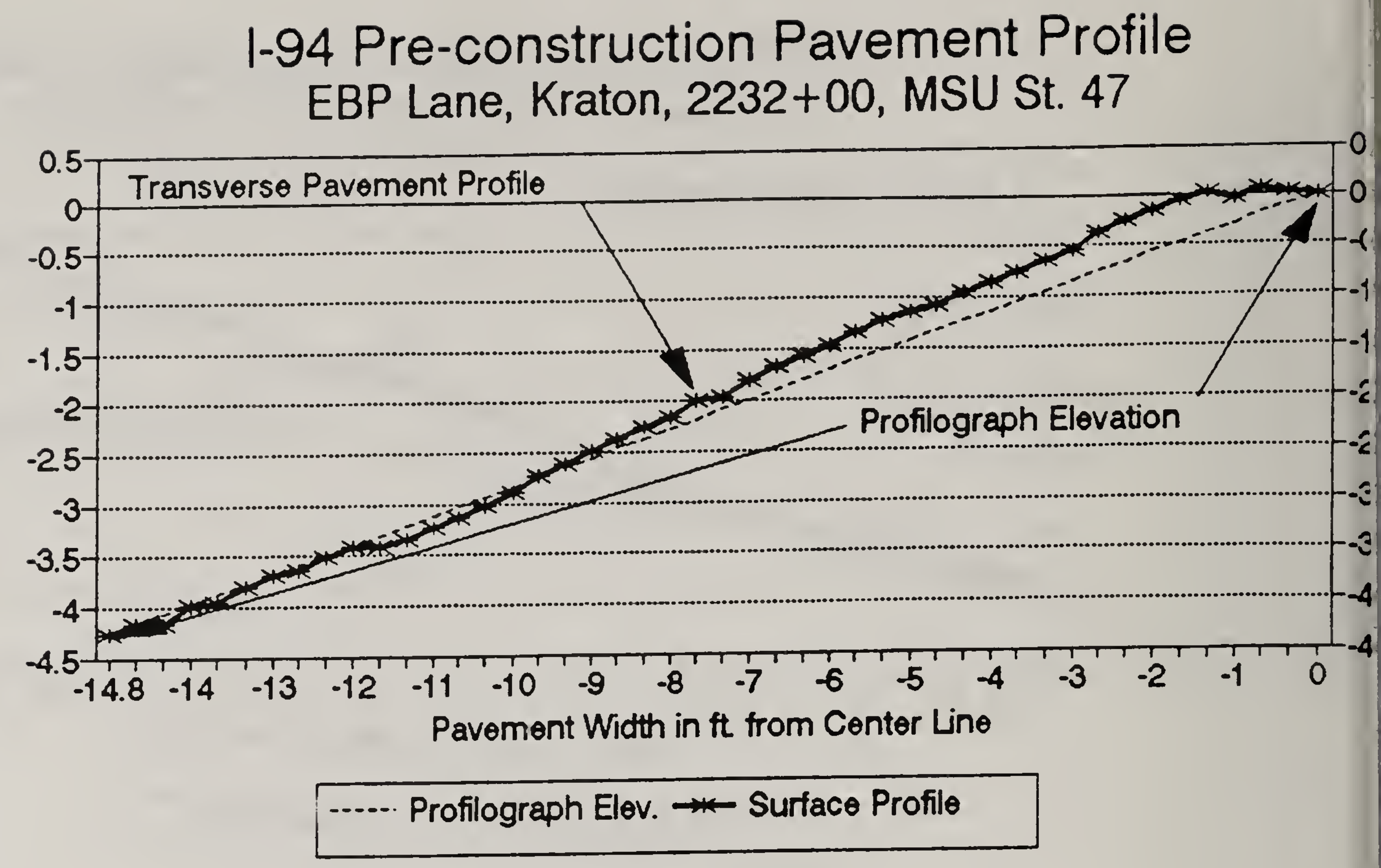


Fig. 23B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Pre-construction Pavement Profile
EBP Lane, Kraton, 2232+00, MSU St. 47

Note: East Bound Passing (EBP) Lane, Kraton Modified Binder Section

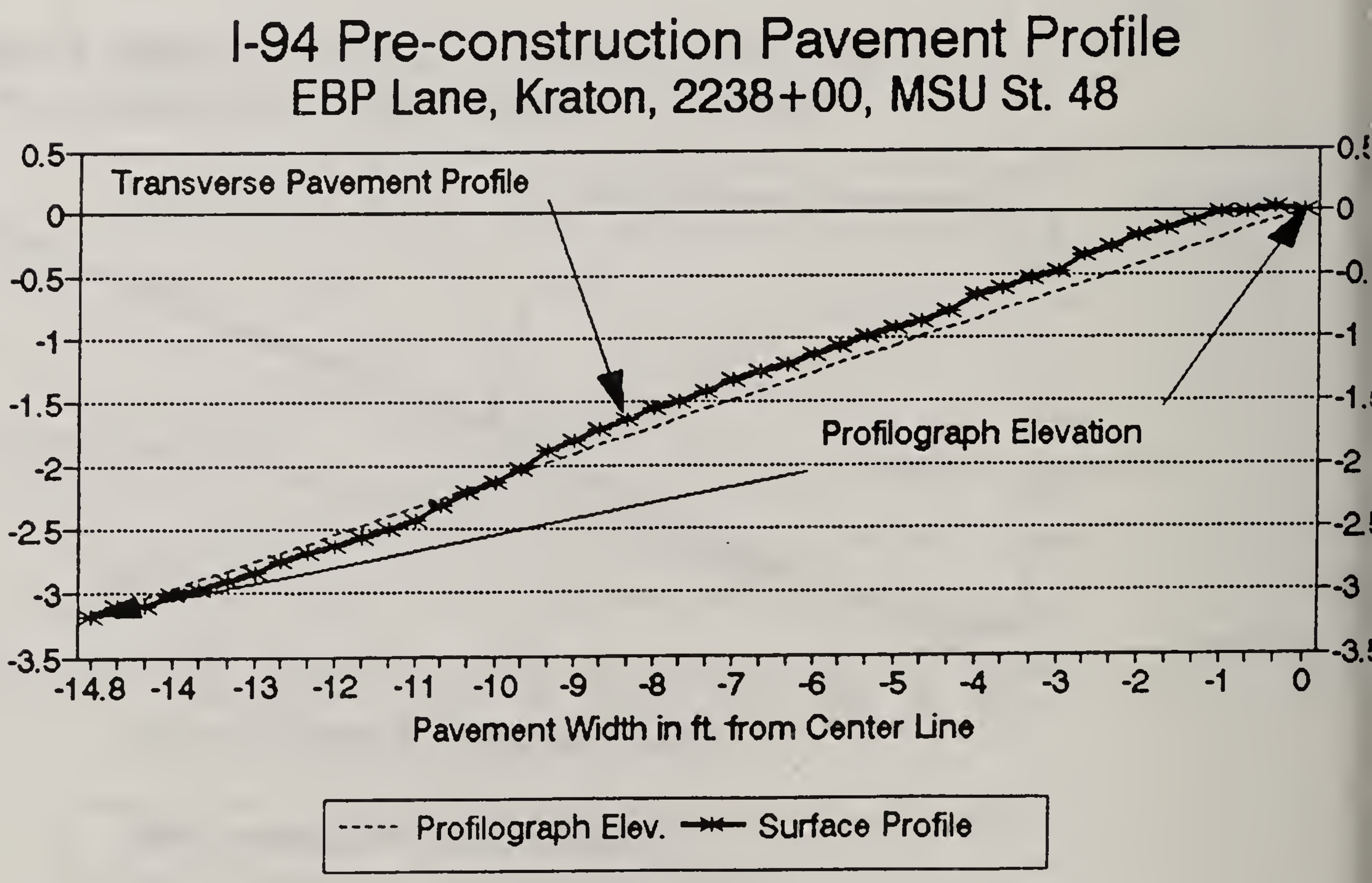
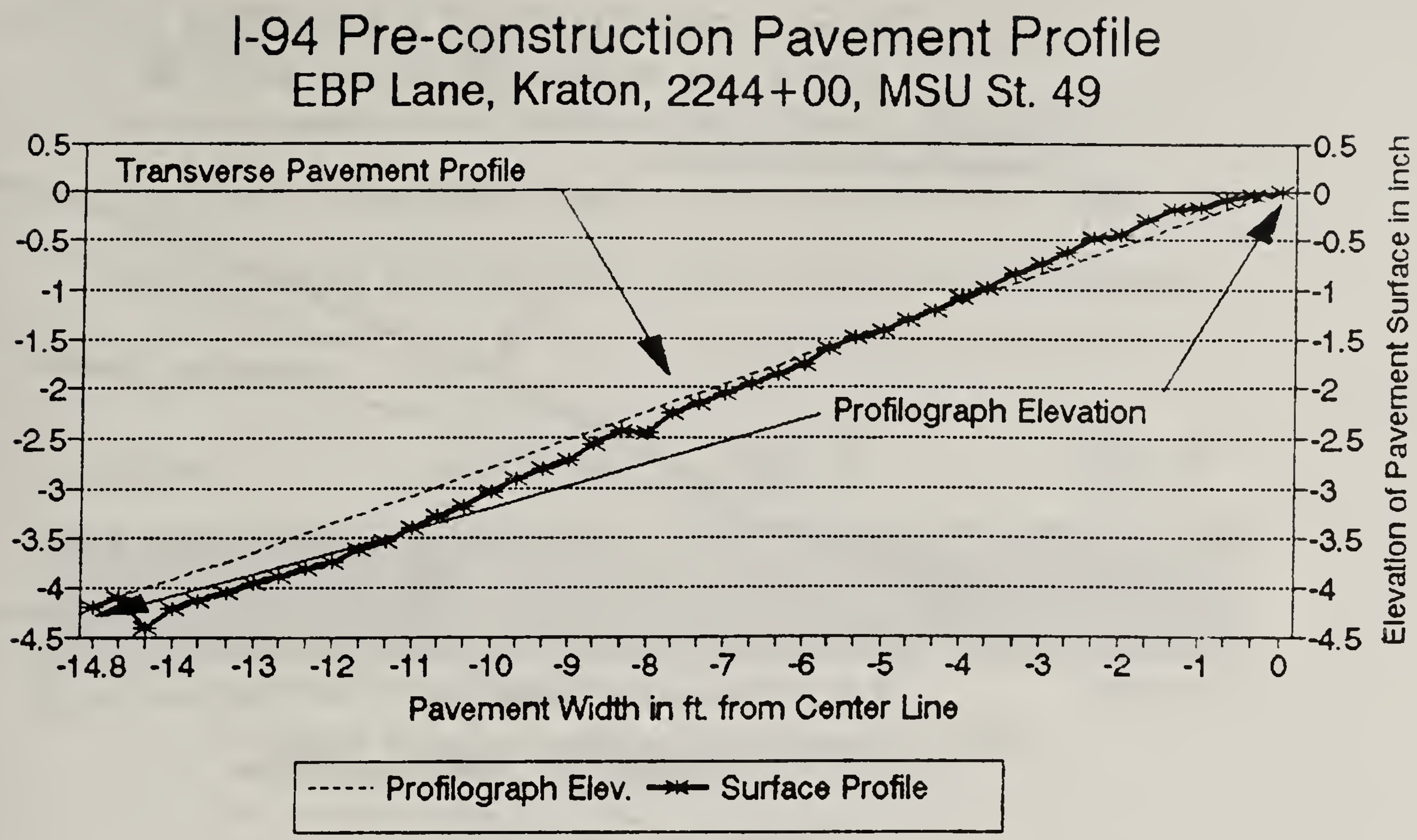

I-94 Pre-construction Pavement Profile
EBP Lane, Kraton, 2238+00, MSU St. 48

Fig. 24B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Kraton Modified Binder Section

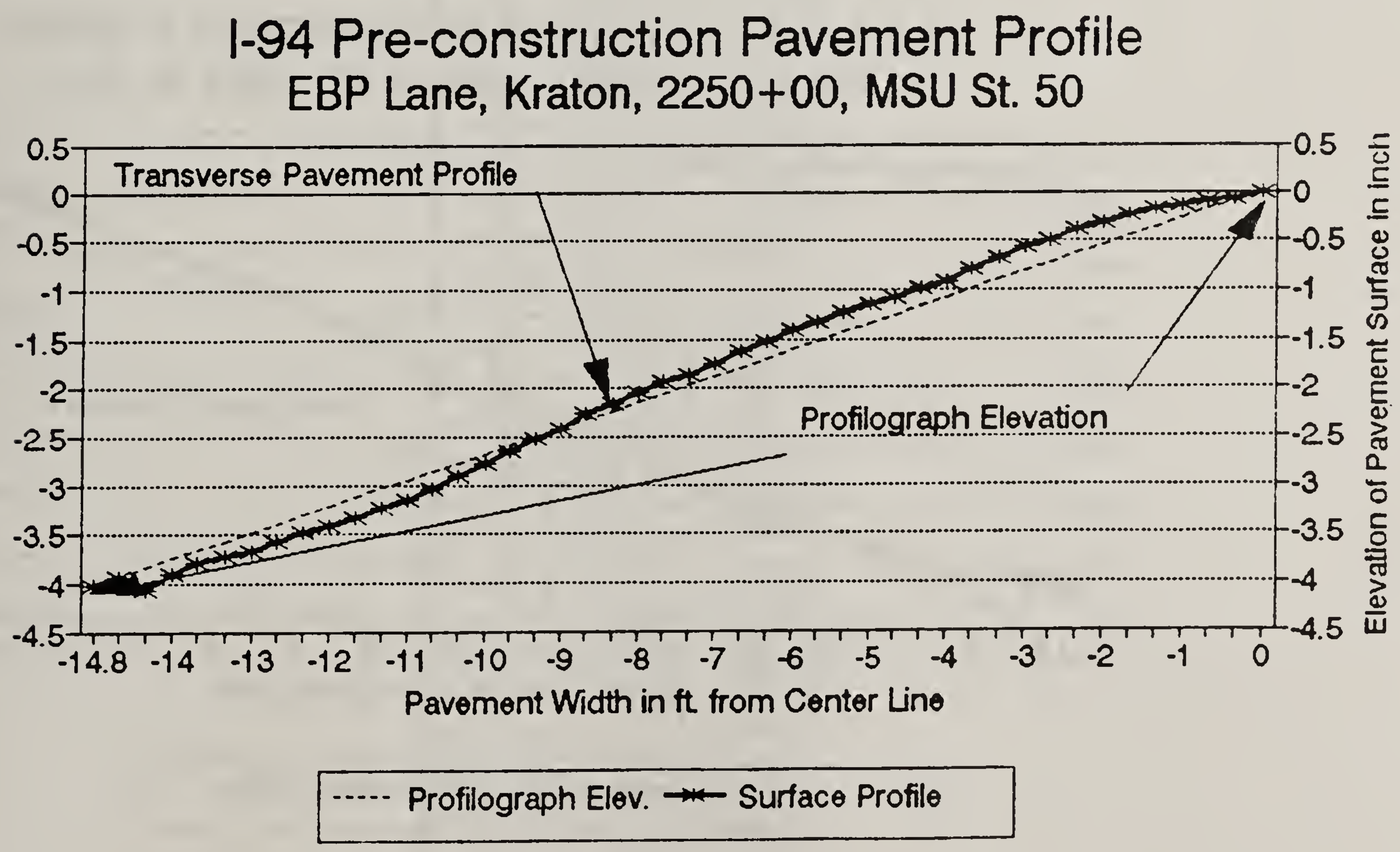
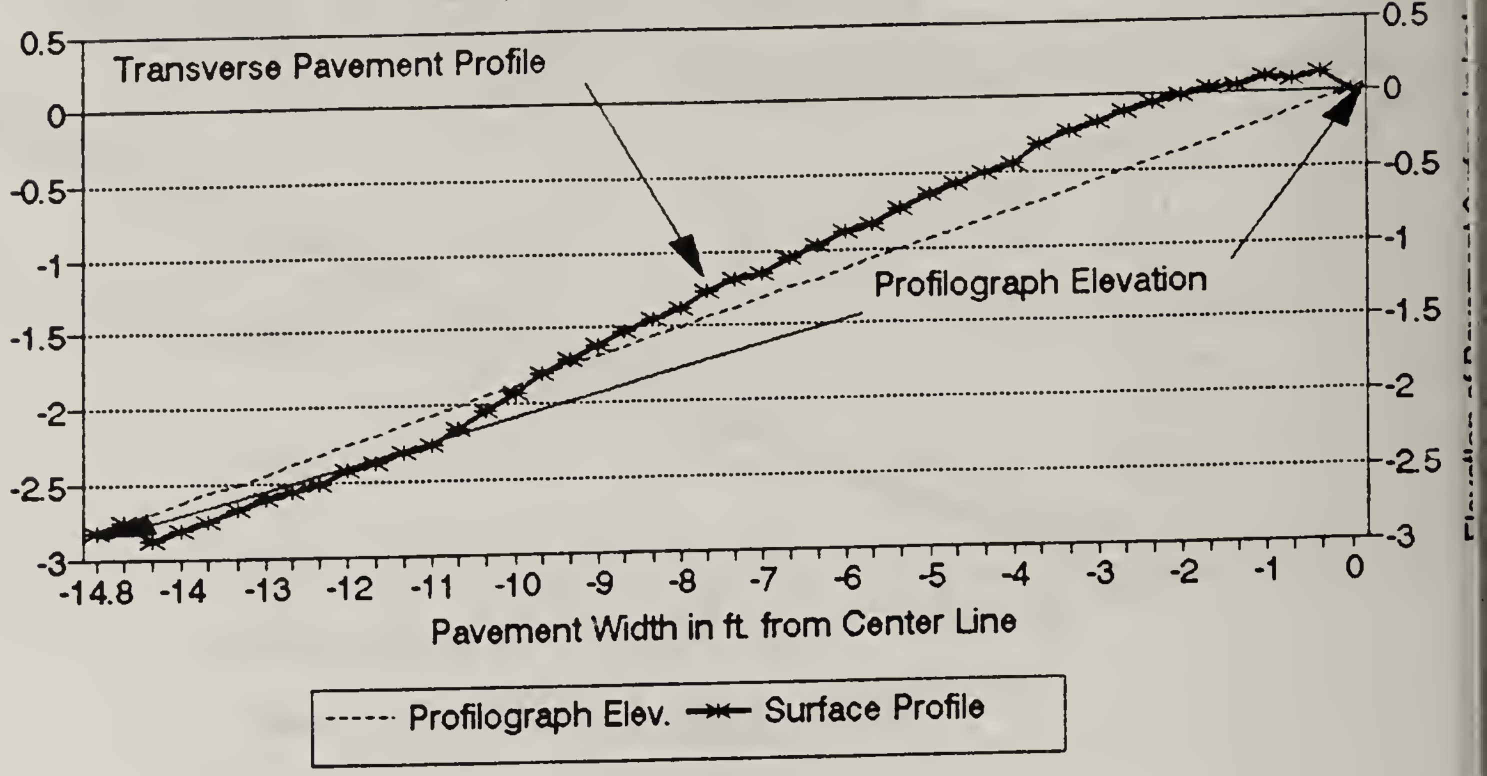
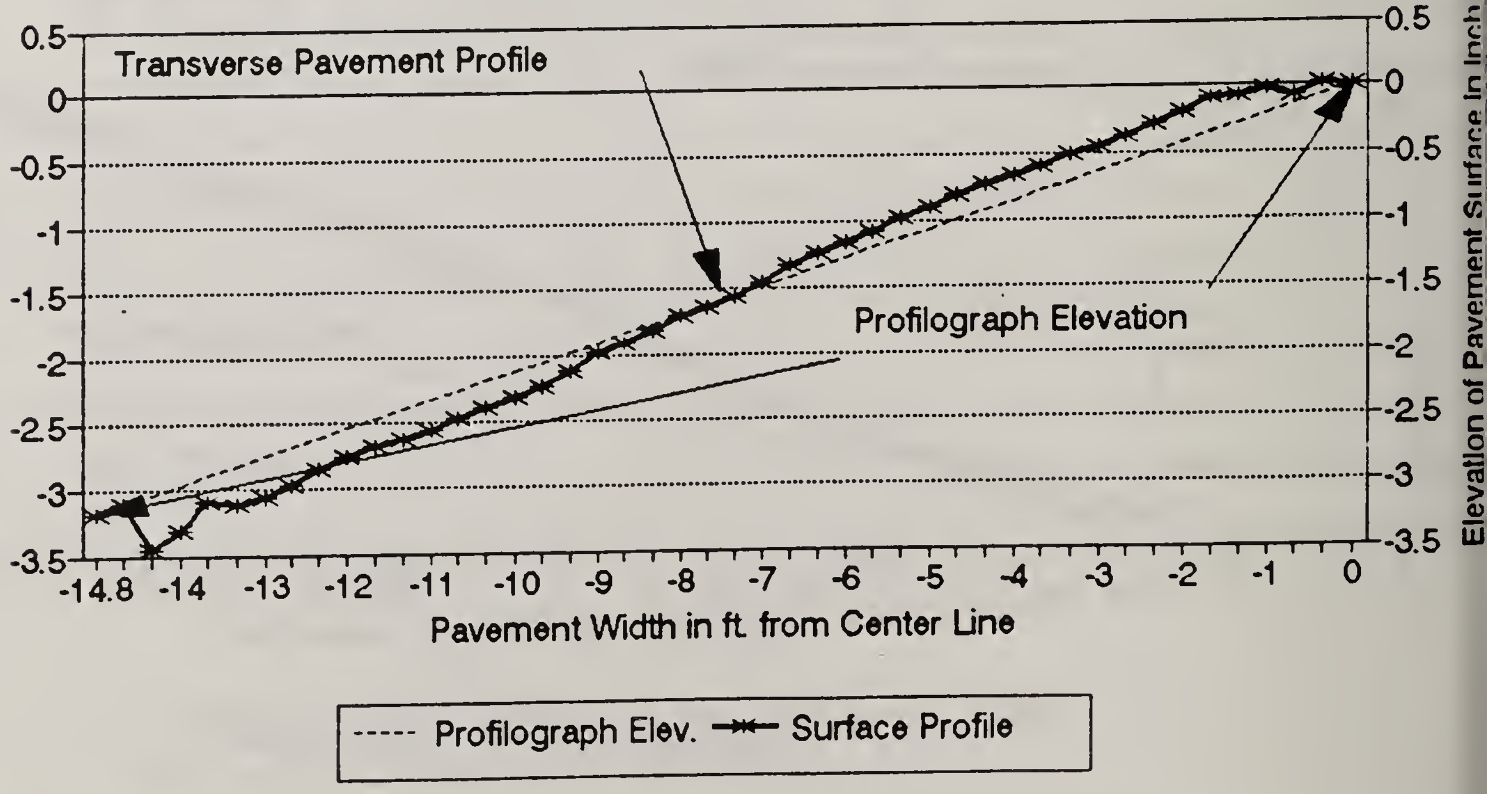


Fig. 25B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin



I-94 Pre-construction Pavement Profile
EBP Lane, Kraton, 2254+00, MSU St. 51

Note: East Bound Passing (EBP) Lane, Kraton Modified Binder Section

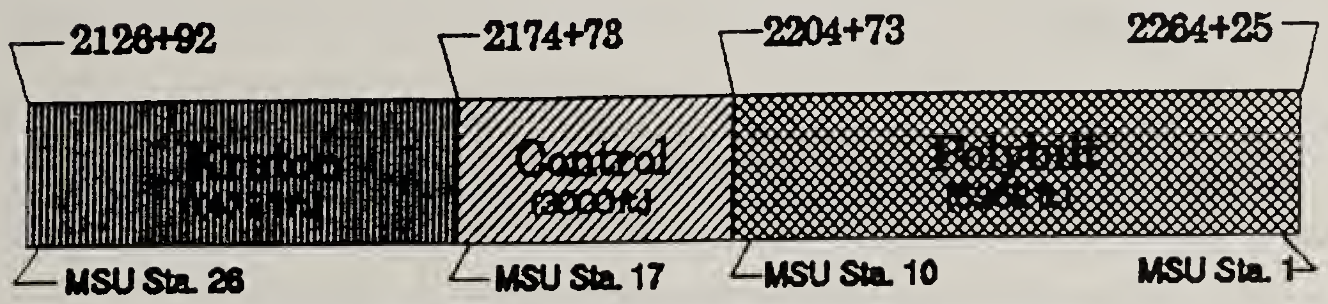


I-94 Pre-construction Pavement Profile
EBP Lane, Kraton, 2260+00, MSU St. 52

Fig. 26B. Pre-construction Profile and Elevation, Center Line of Pavement as Origin

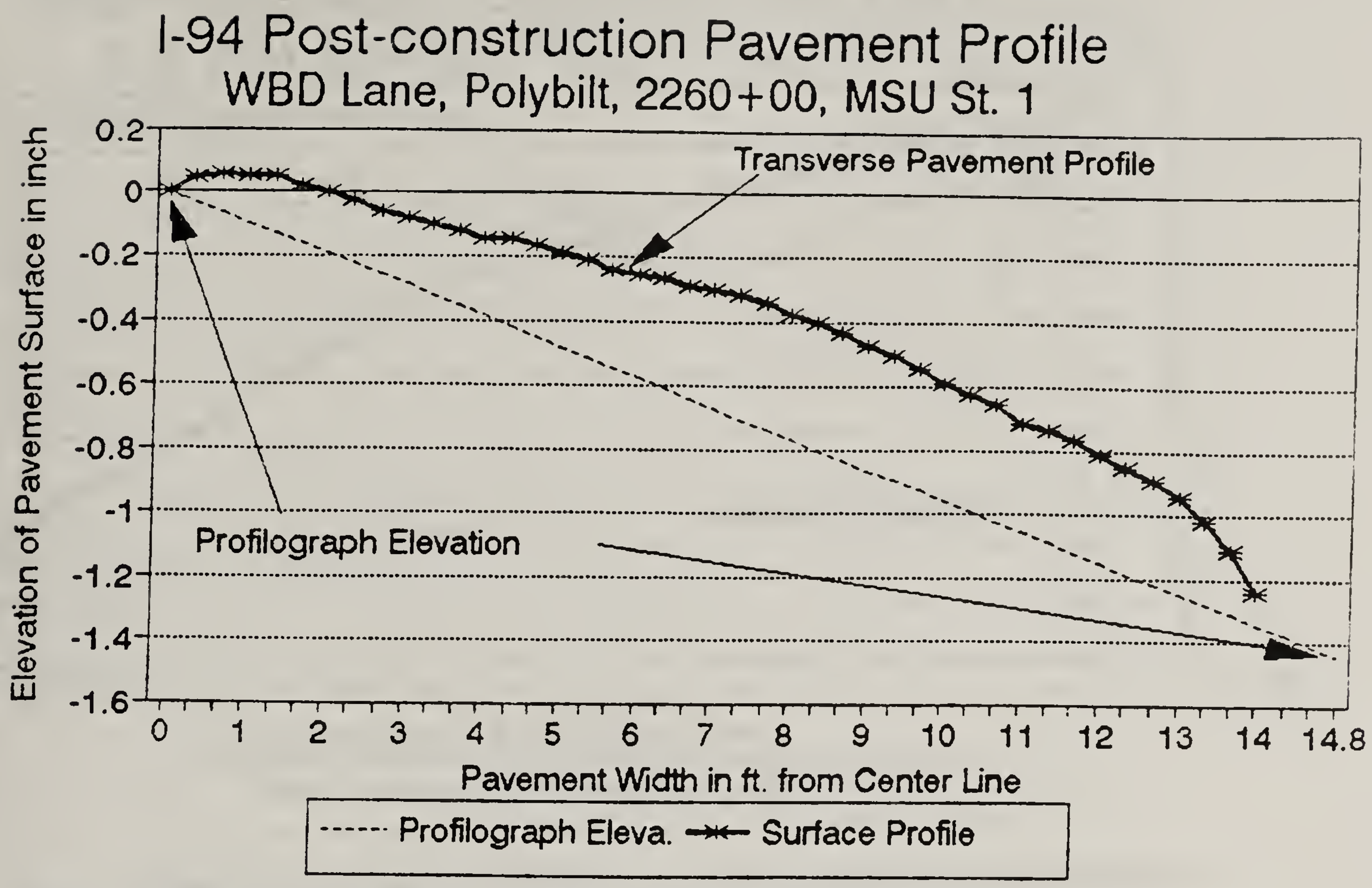
Appendix M

- Figures 1C through 13C - Post-construction Pavement Profile and Elevation of West Bound Driving Lane
- Figures 1D through 13D - Post-construction Pavement Profile and Elevation of West Bound Passing Lane



West Bound Interstate Highway I-94

MSU Station Number	Highway Station	Section by Binder Used
1	2260+00	Polybilt
2	2254+00	Polybilt
3	2250+00	Polybilt
4	2244+00	Polybilt
5	2238+00	Polybilt
6	2232+00	Polybilt
7	2226+00	Polybilt
8	2220+00	Polybilt
9	2214+00	Polybilt
10	2208+00	Polybilt
11	2200+00	Exxon
12	2196+00	Exxon
13	2192+00	Exxon
14	2188+00	Exxon
15	2184+00	Exxon
16	2180+00	Exxon
17	2176+00	Exxon
18	2170+00	Kraton
19	2164+00	Kraton
20	2160+00	Kraton
21	2154+00	Kraton
22	2150+00	Kraton
23	2144+00	Kraton
24	2138+00	Kraton
25	2134+00	Kraton
26	2130+00	Kraton



Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section

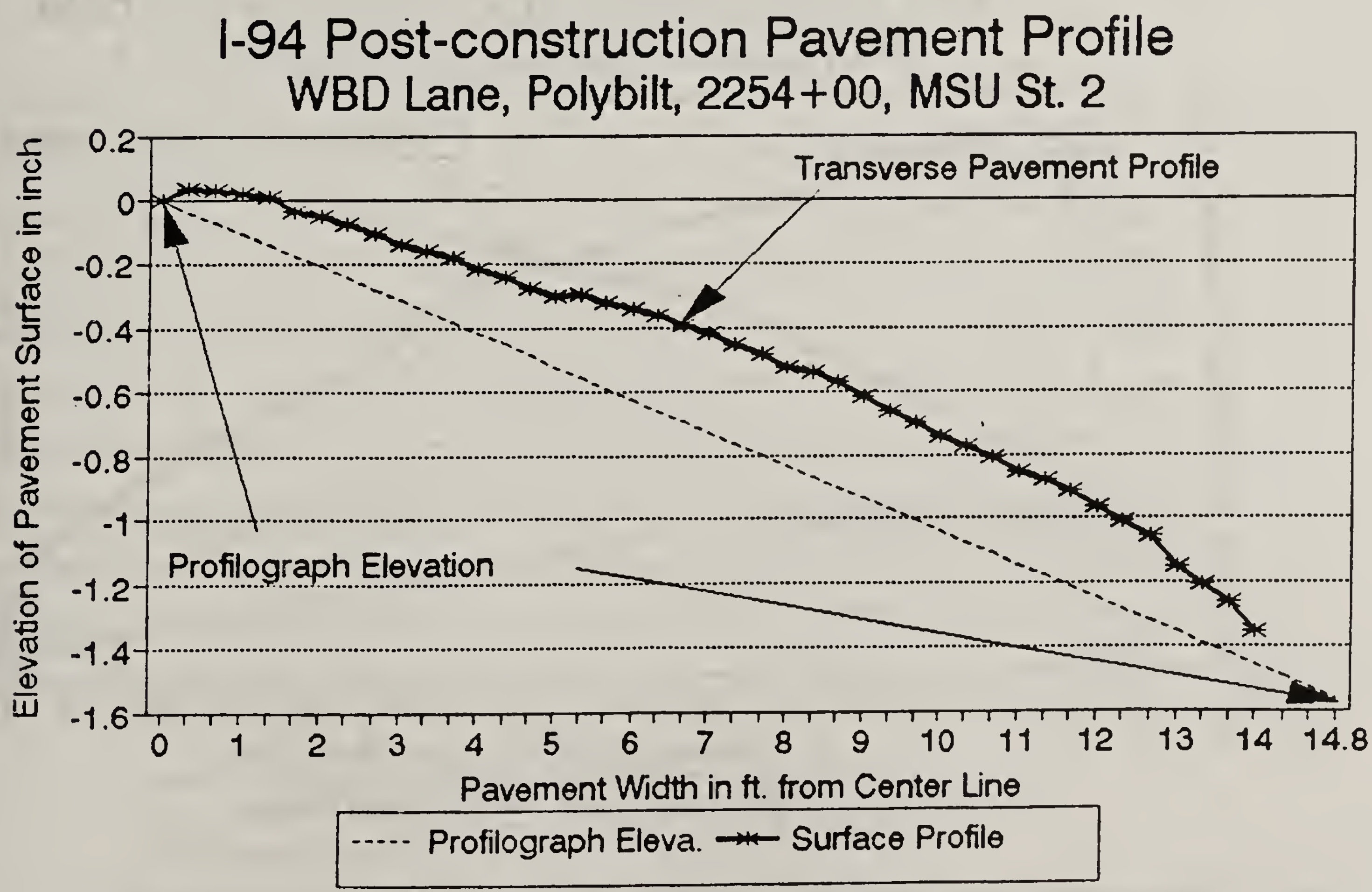
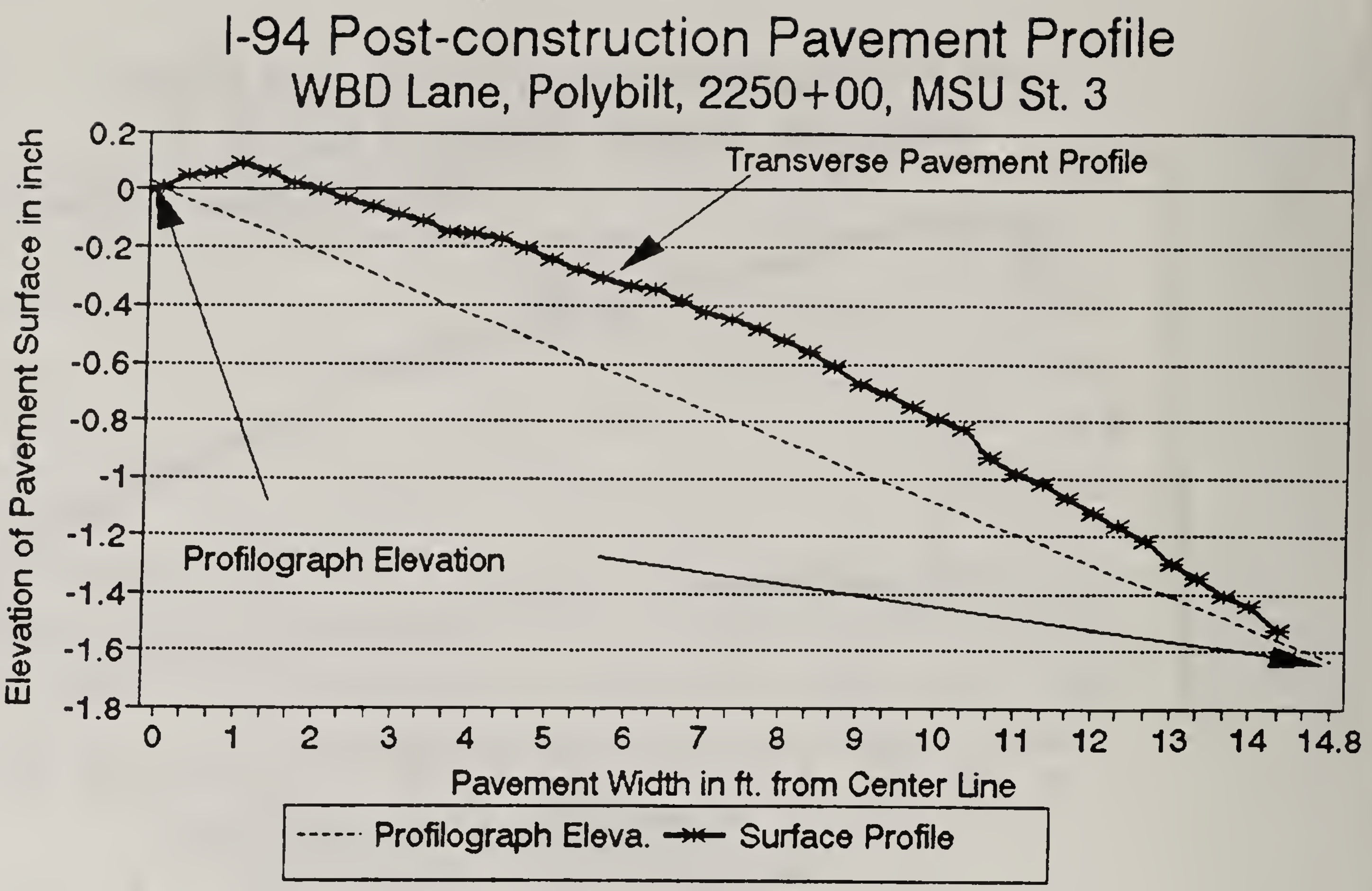


Fig. 1C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section

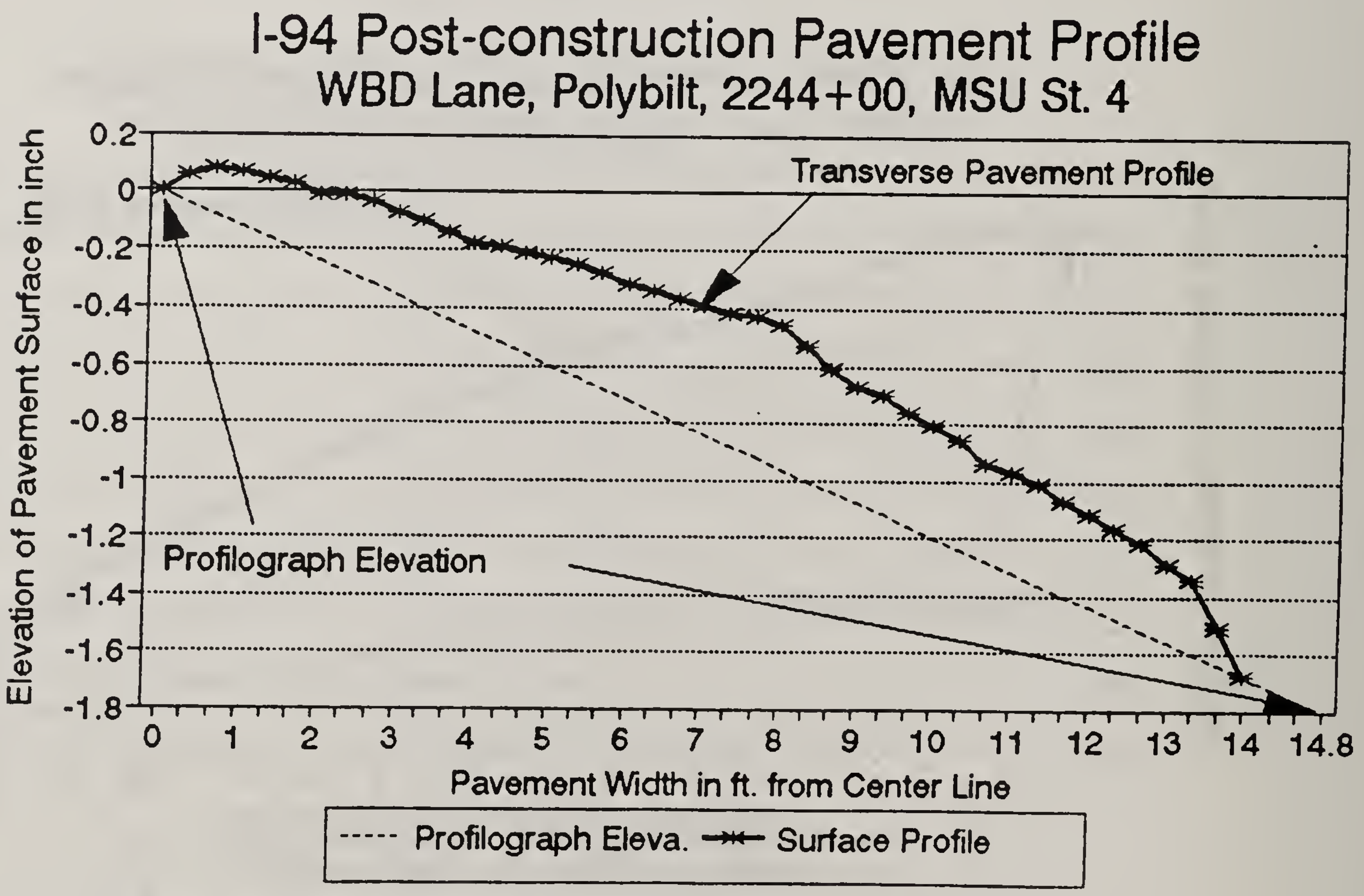
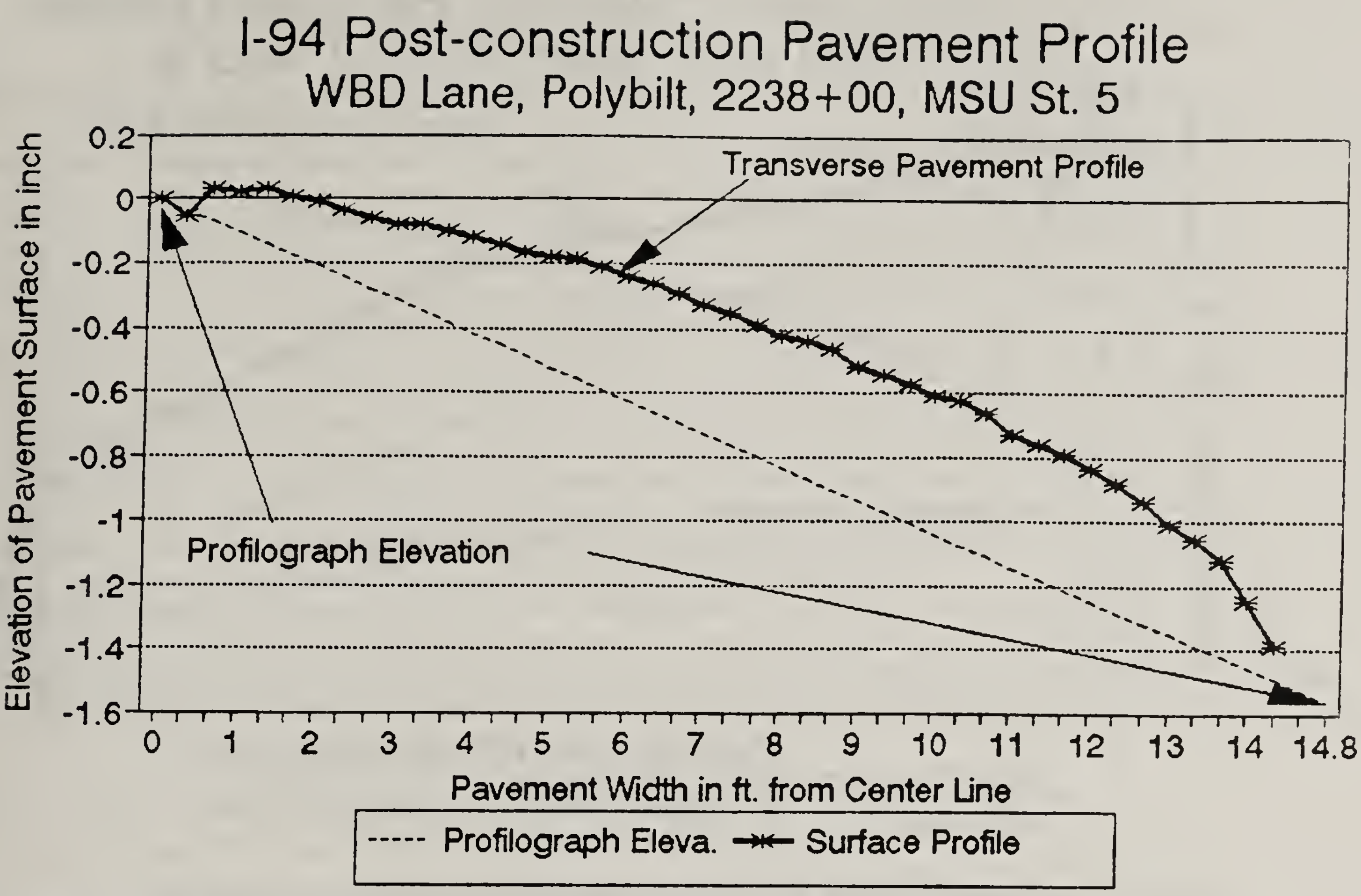


Fig. 2C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section

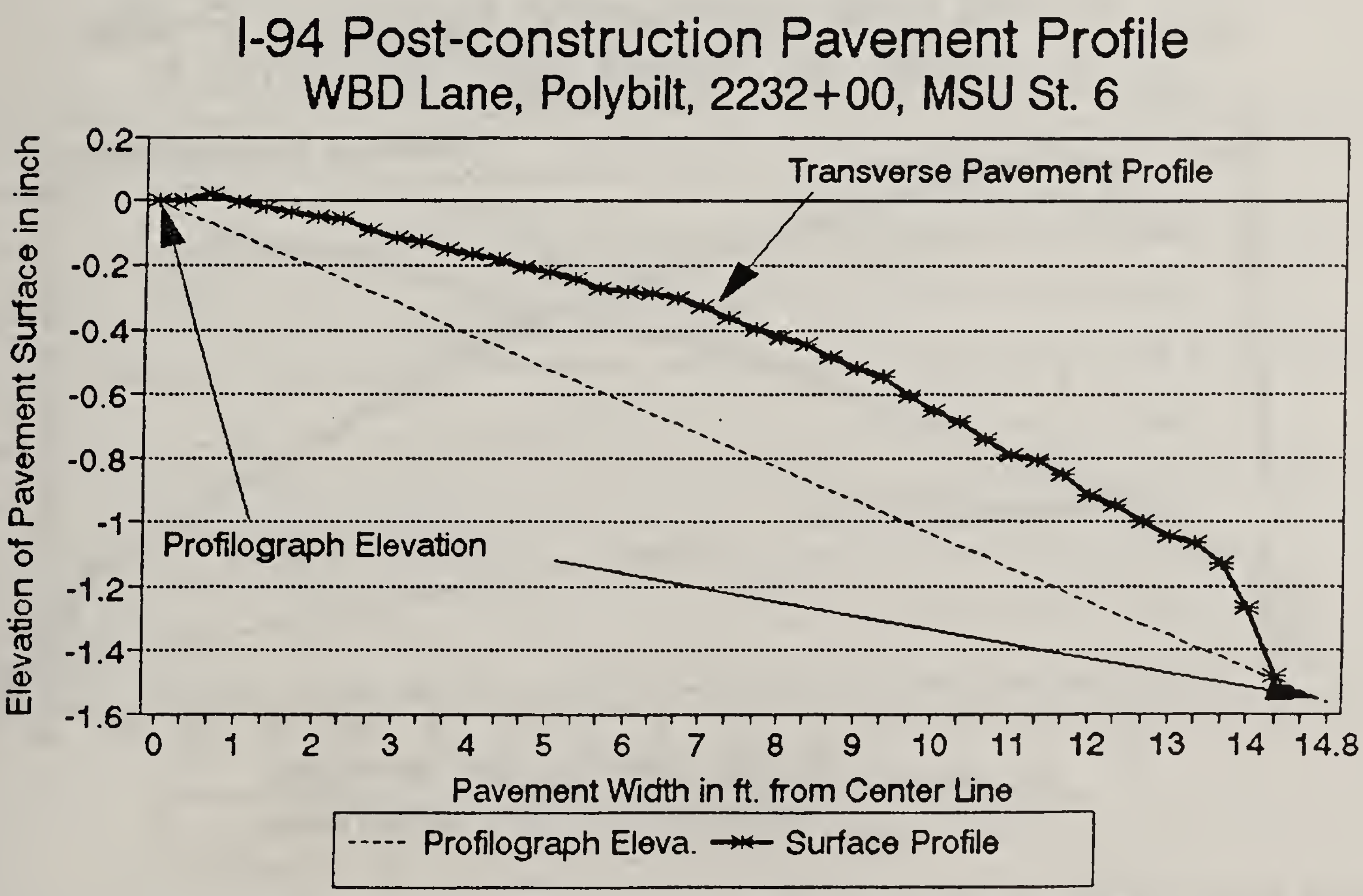
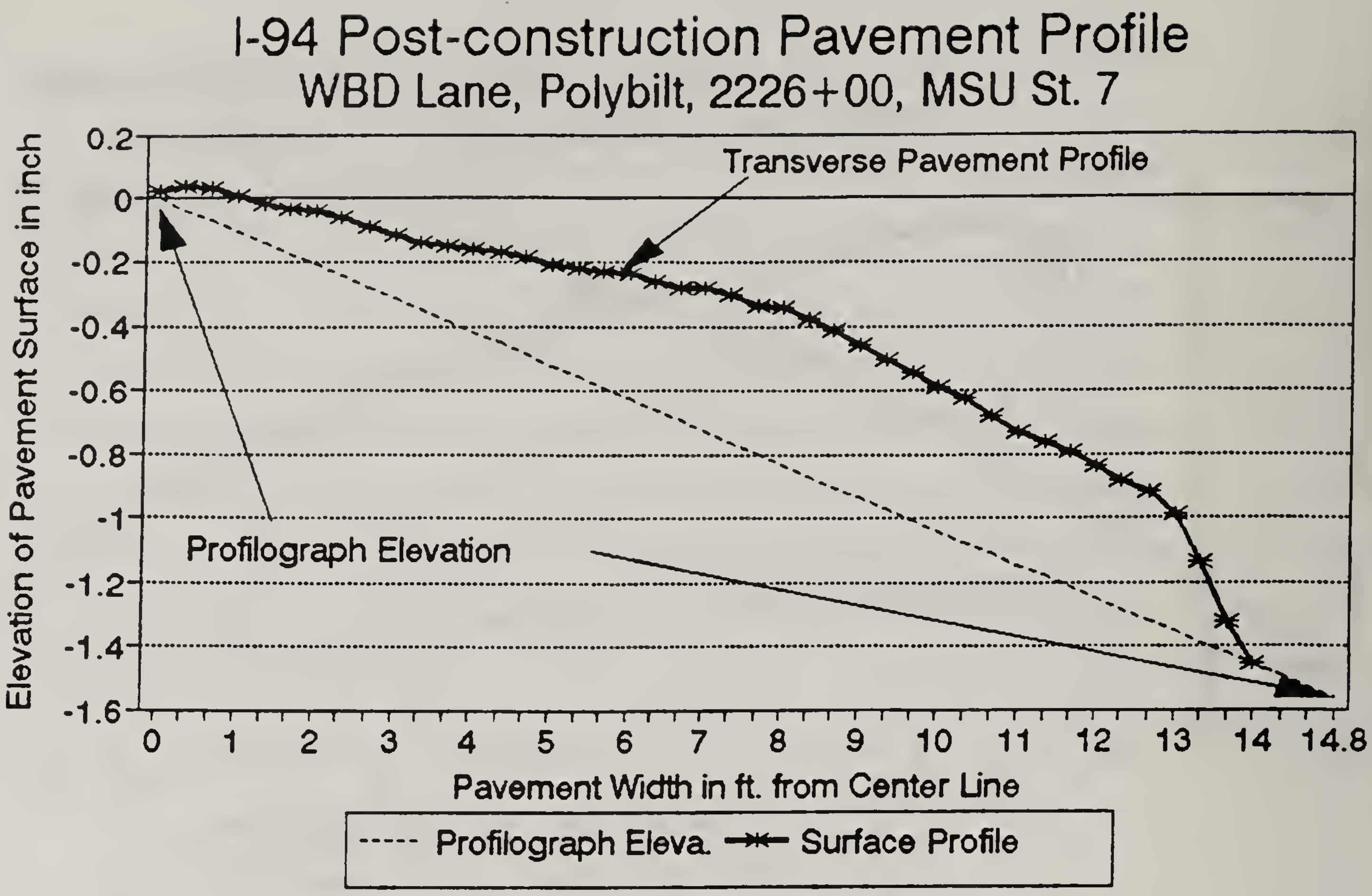


Fig. 3C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section

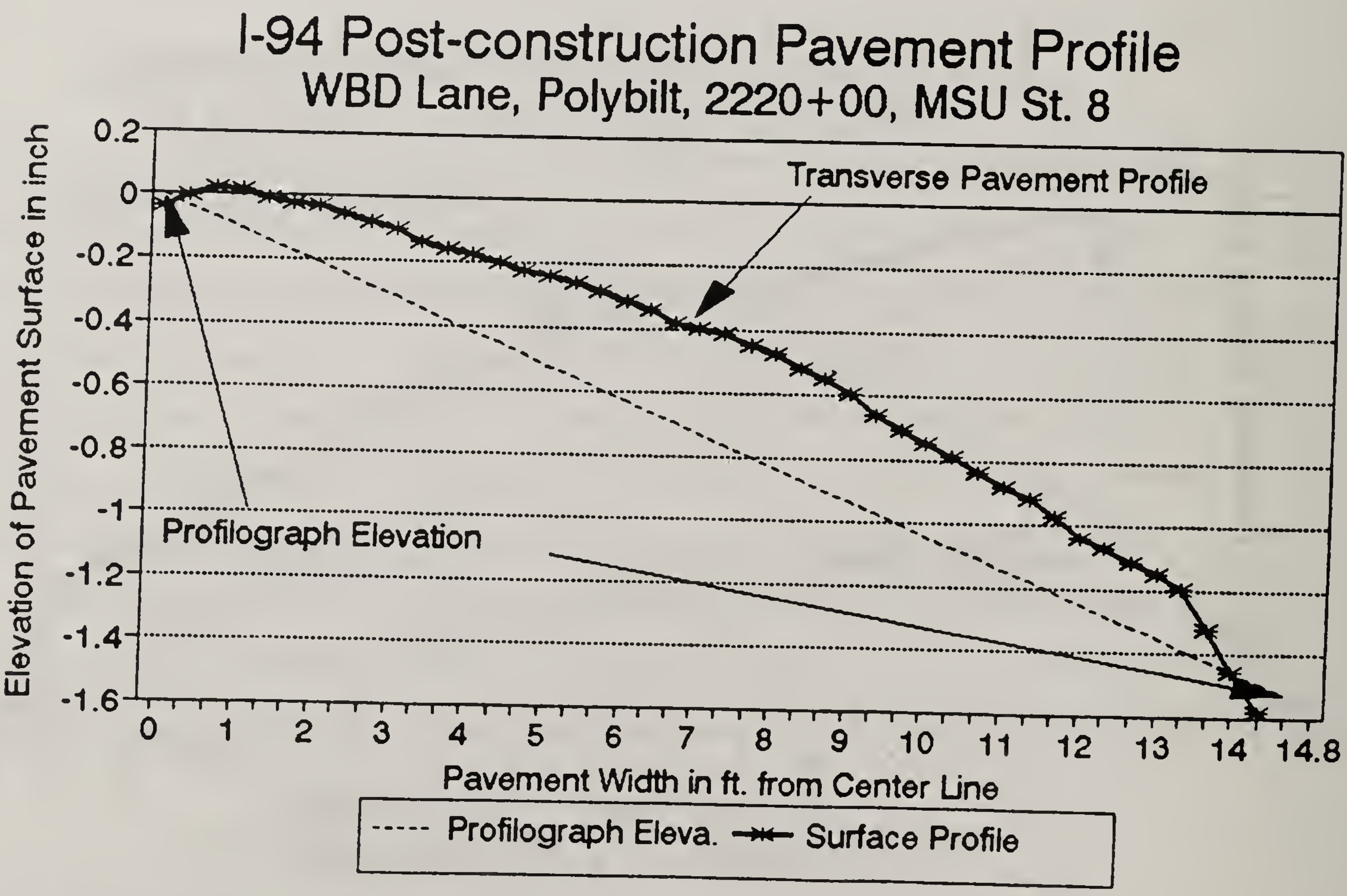
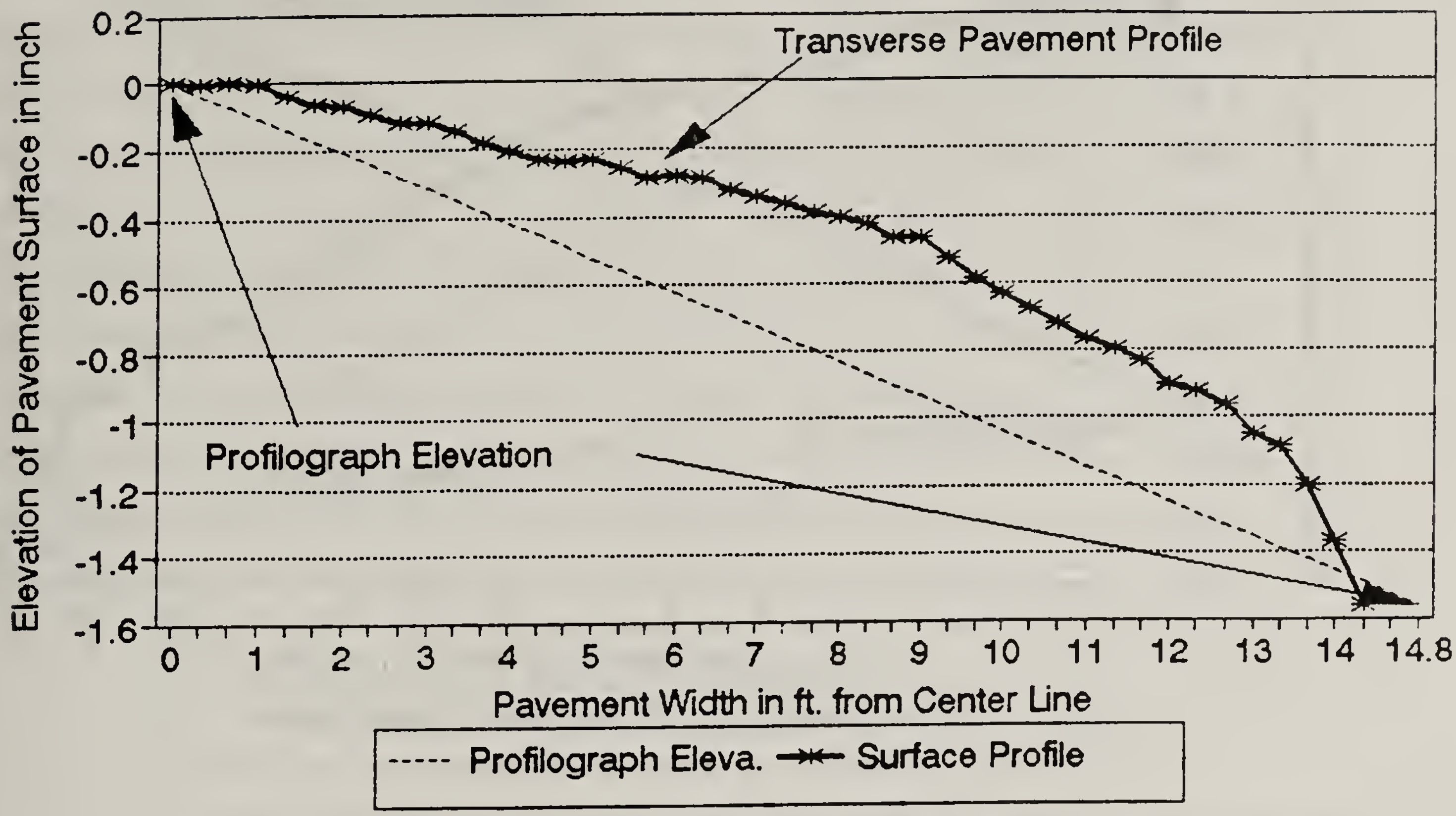


Fig. 4C. Post-construction Profile and Elevation, Center Line of Pavement as Origin

I-94 Post-construction Pavement Profile
WBD Lane, Polybilt, 2214+00, MSU St. 9



Note: West Bound Driving (WBD) Lane, Polybilt Modified Binder Section

I-94 Post-construction Pavement Profile
WBD Lane, Polybilt, 2208+00, MSU St. 10

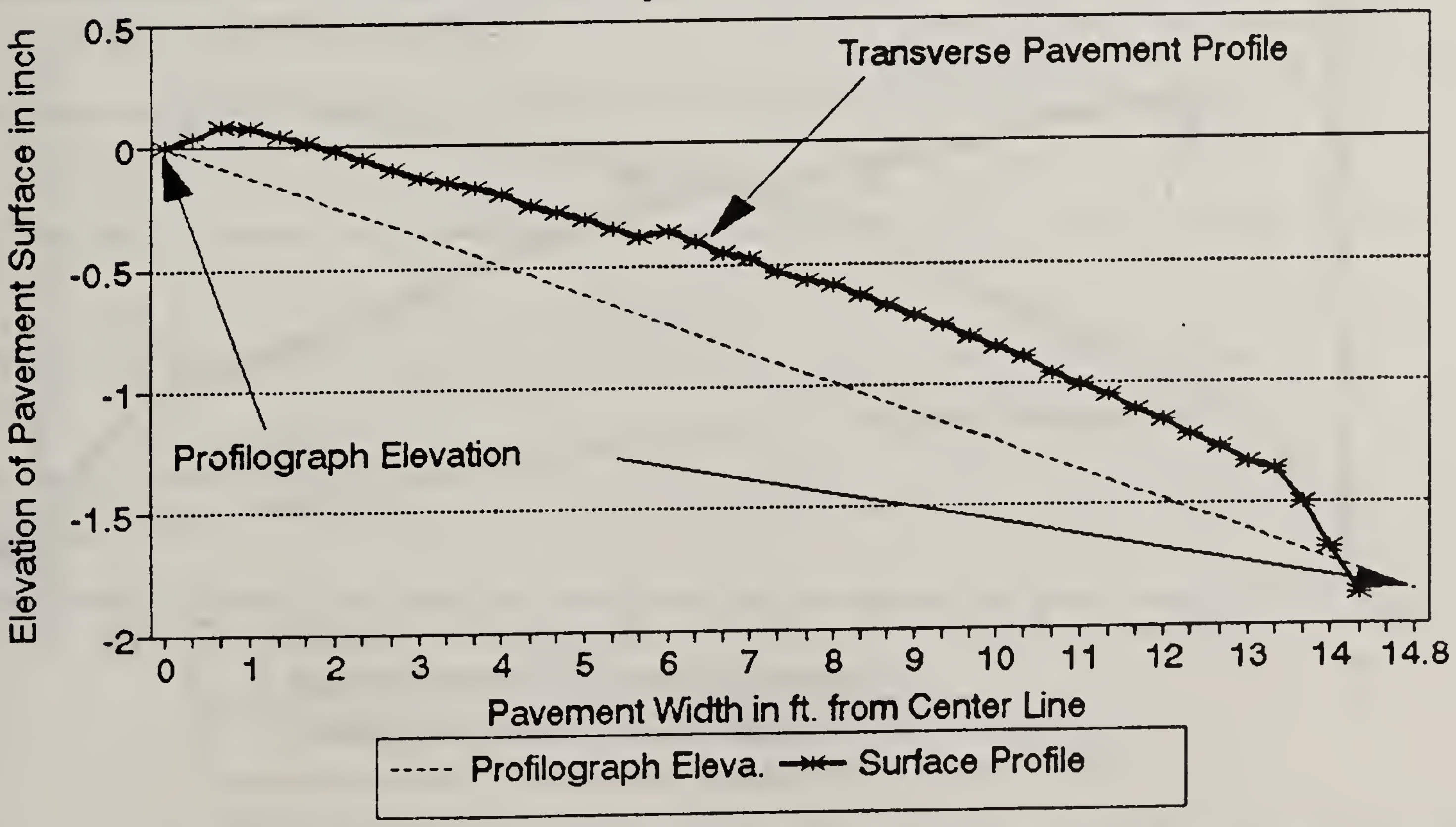
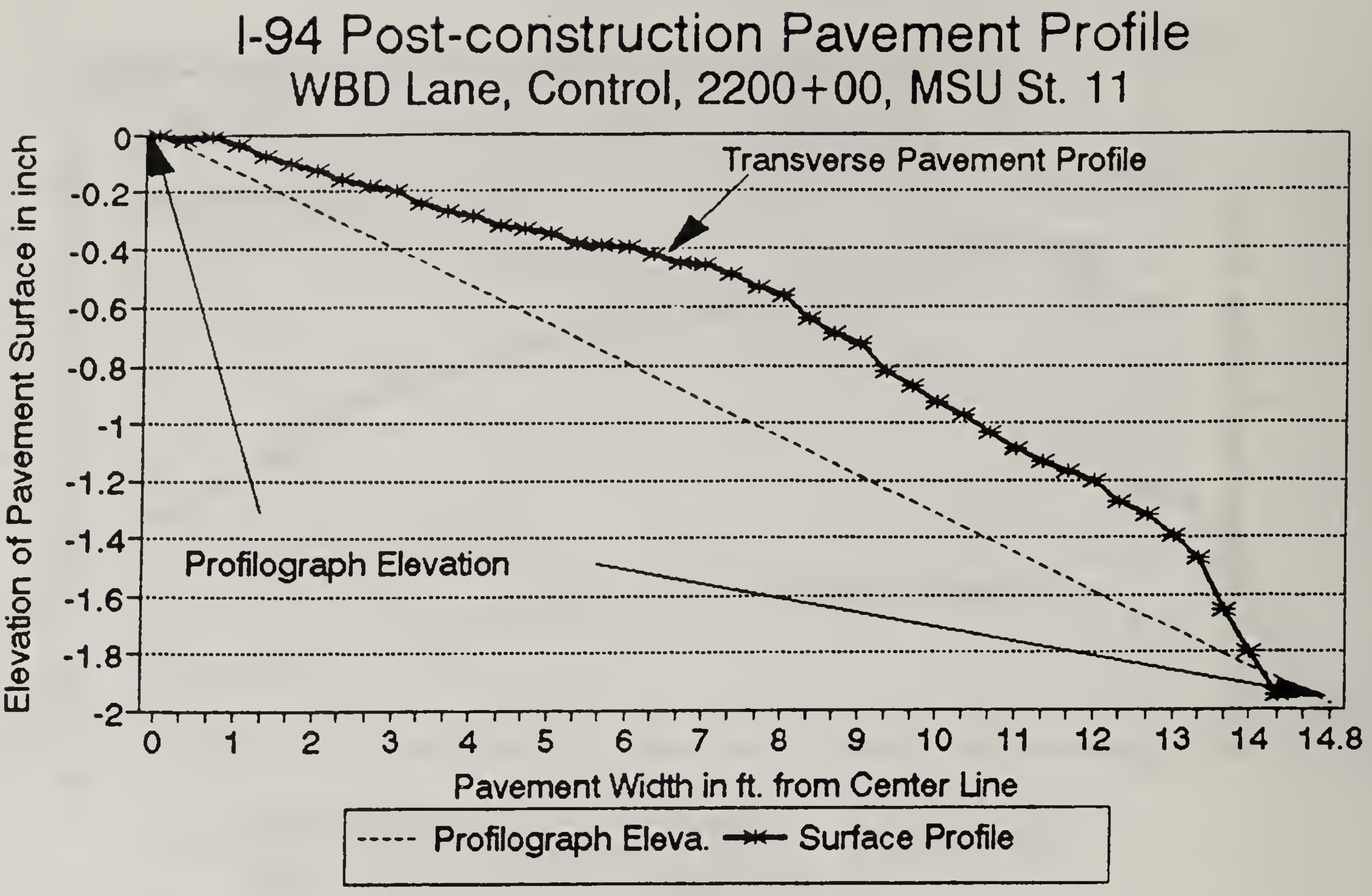


Fig. 5C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Control Section - Unmodified Exxon

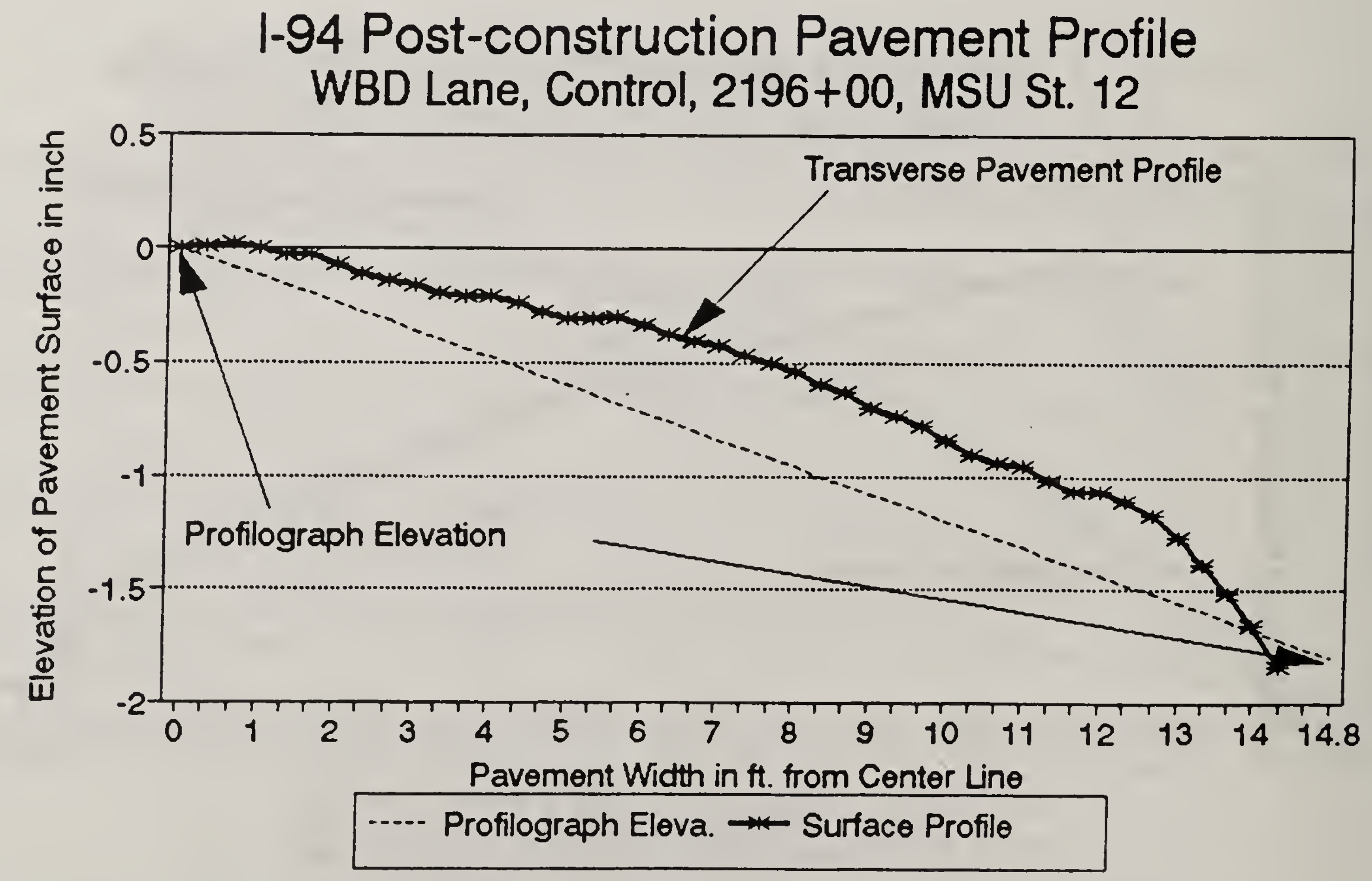
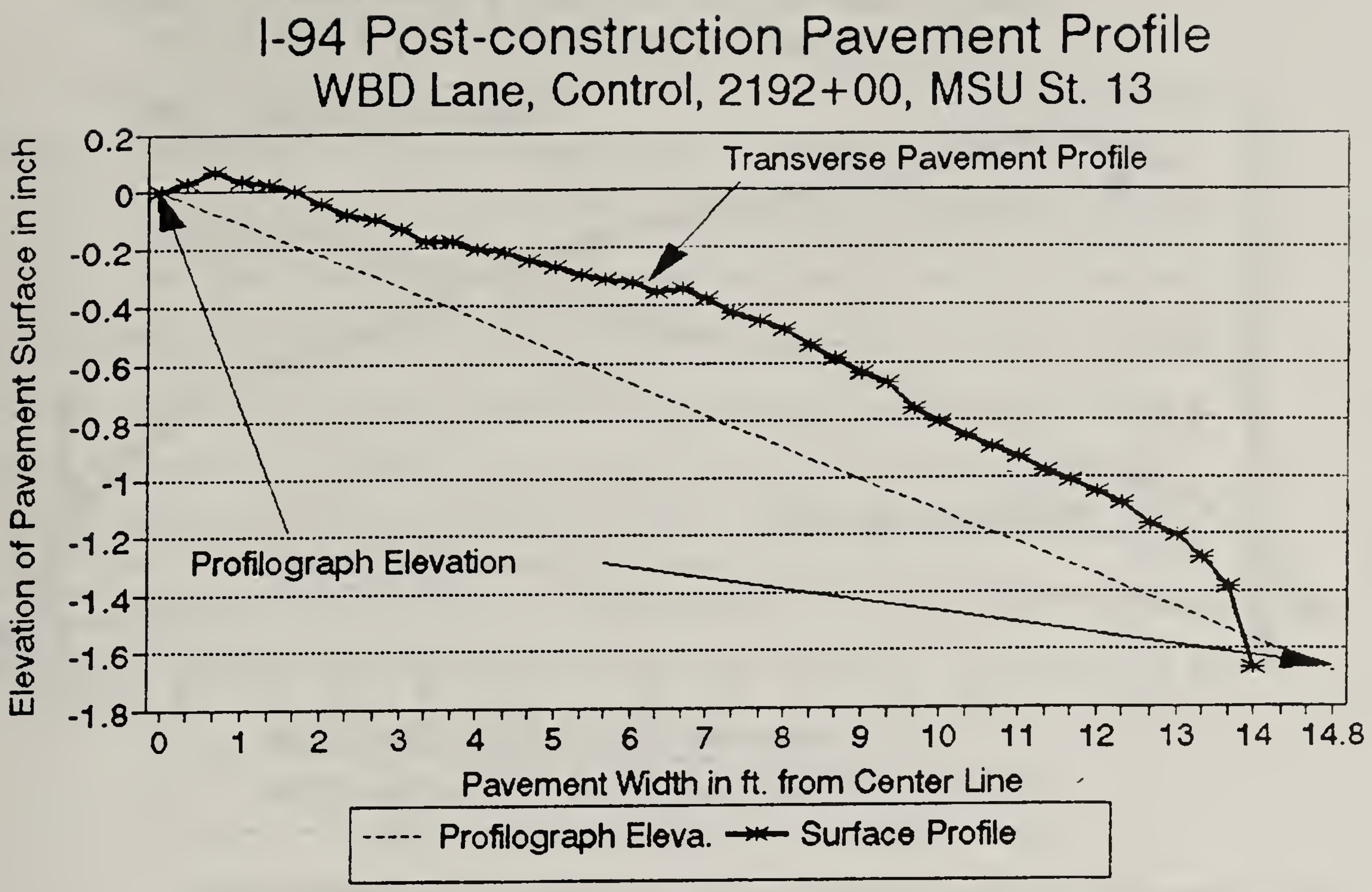


Fig. 6C. Post-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Post-construction Pavement Profile
WBD Lane, Control, 2192+00, MSU St. 13

Note: West Bound Driving (WBD) Lane, Control Section - Unmodified Exxon

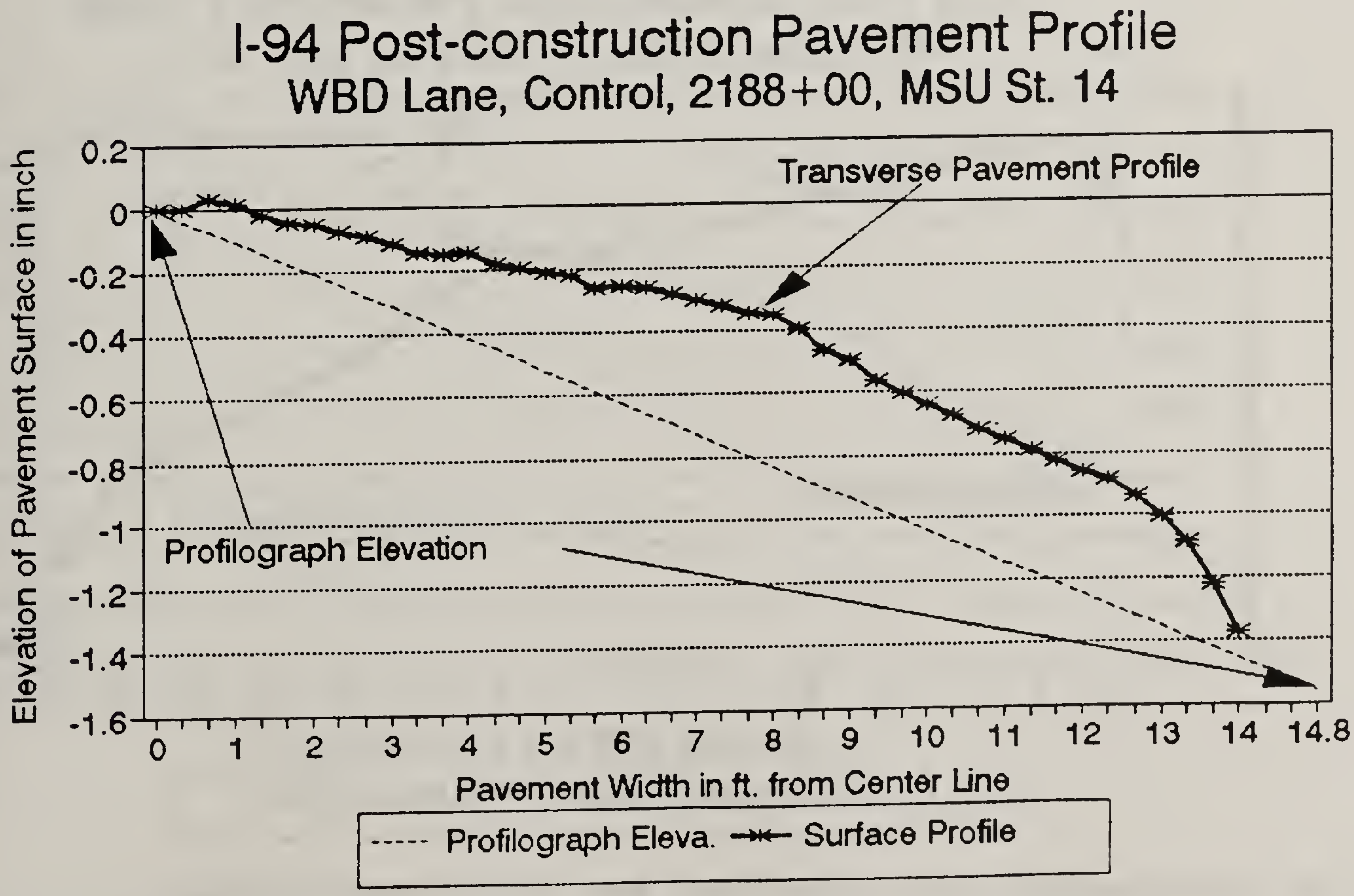
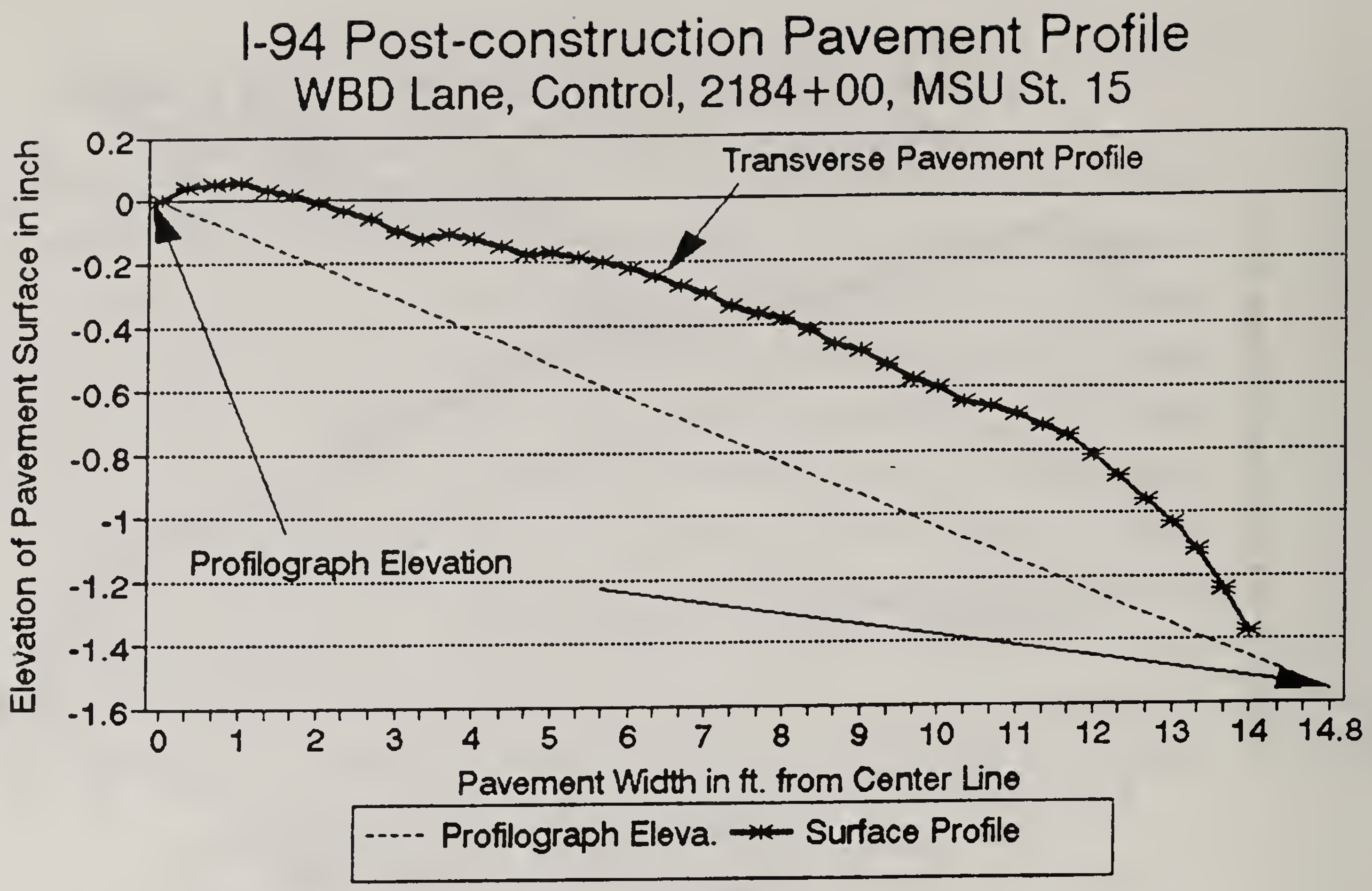

I-94 Post-construction Pavement Profile
WBD Lane, Control, 2188+00, MSU St. 14

Fig. 7C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Control Section - Unmodified Exxon

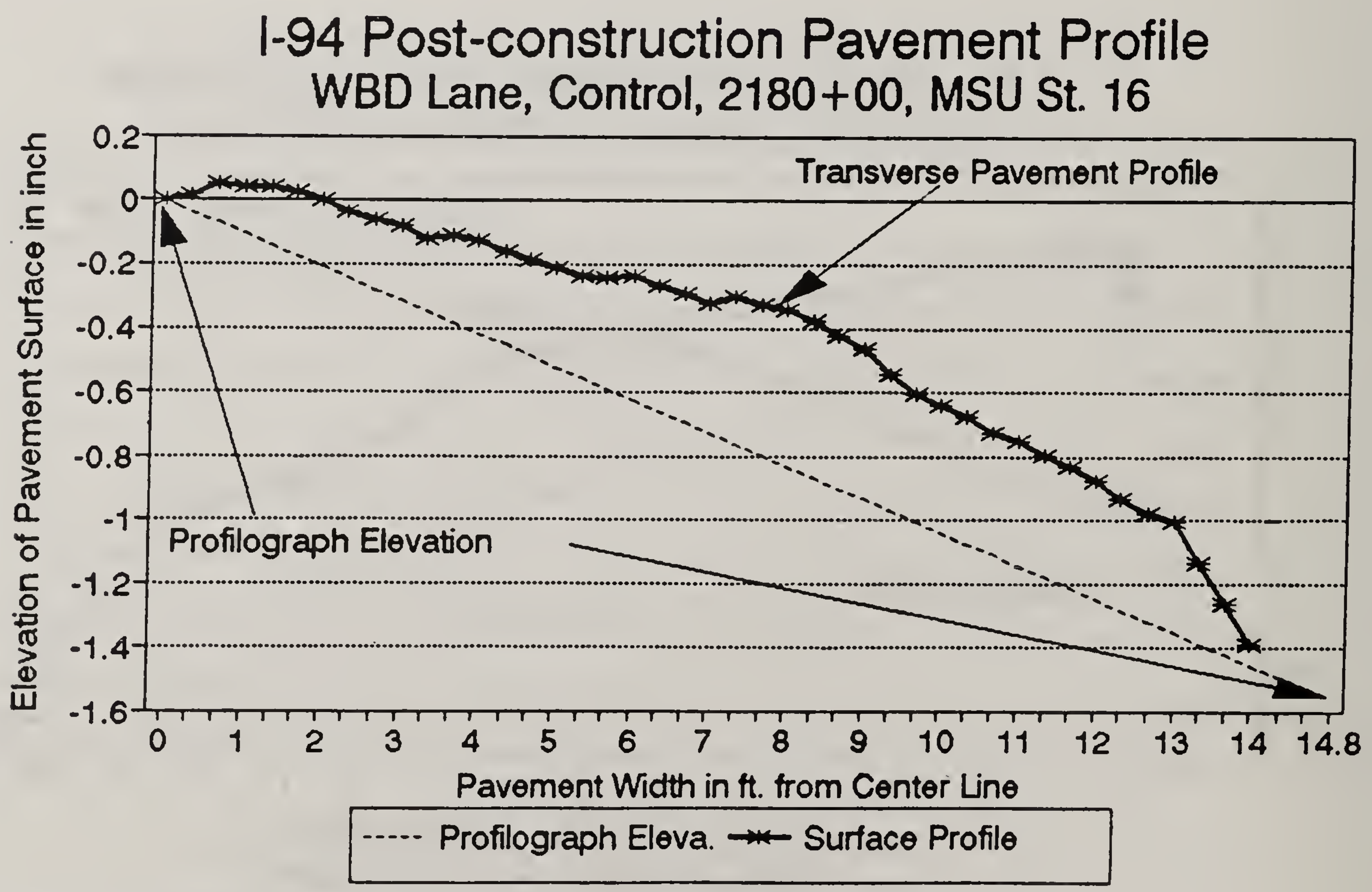
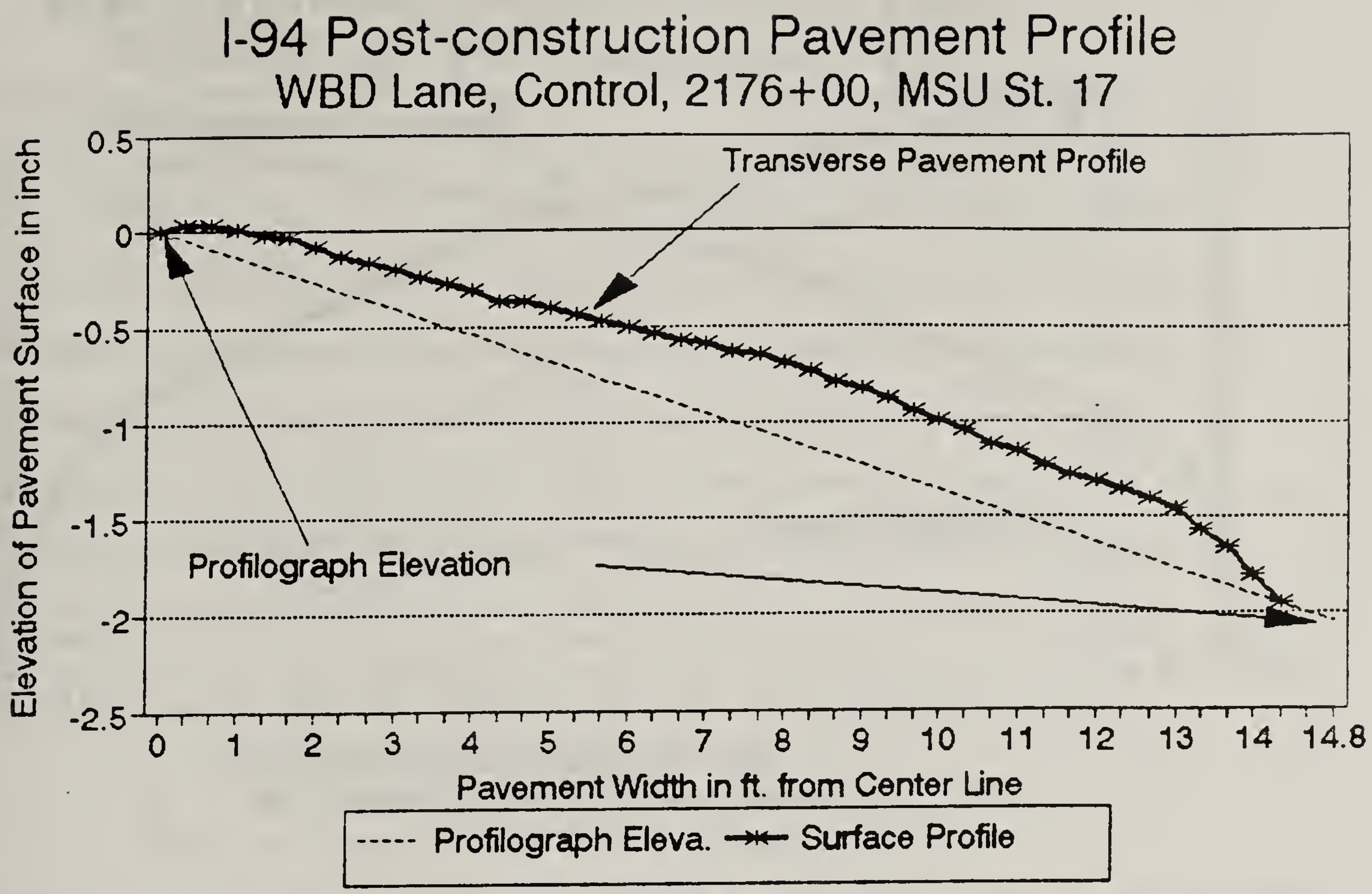


Fig. 8C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Control Section - Unmodified Exxon

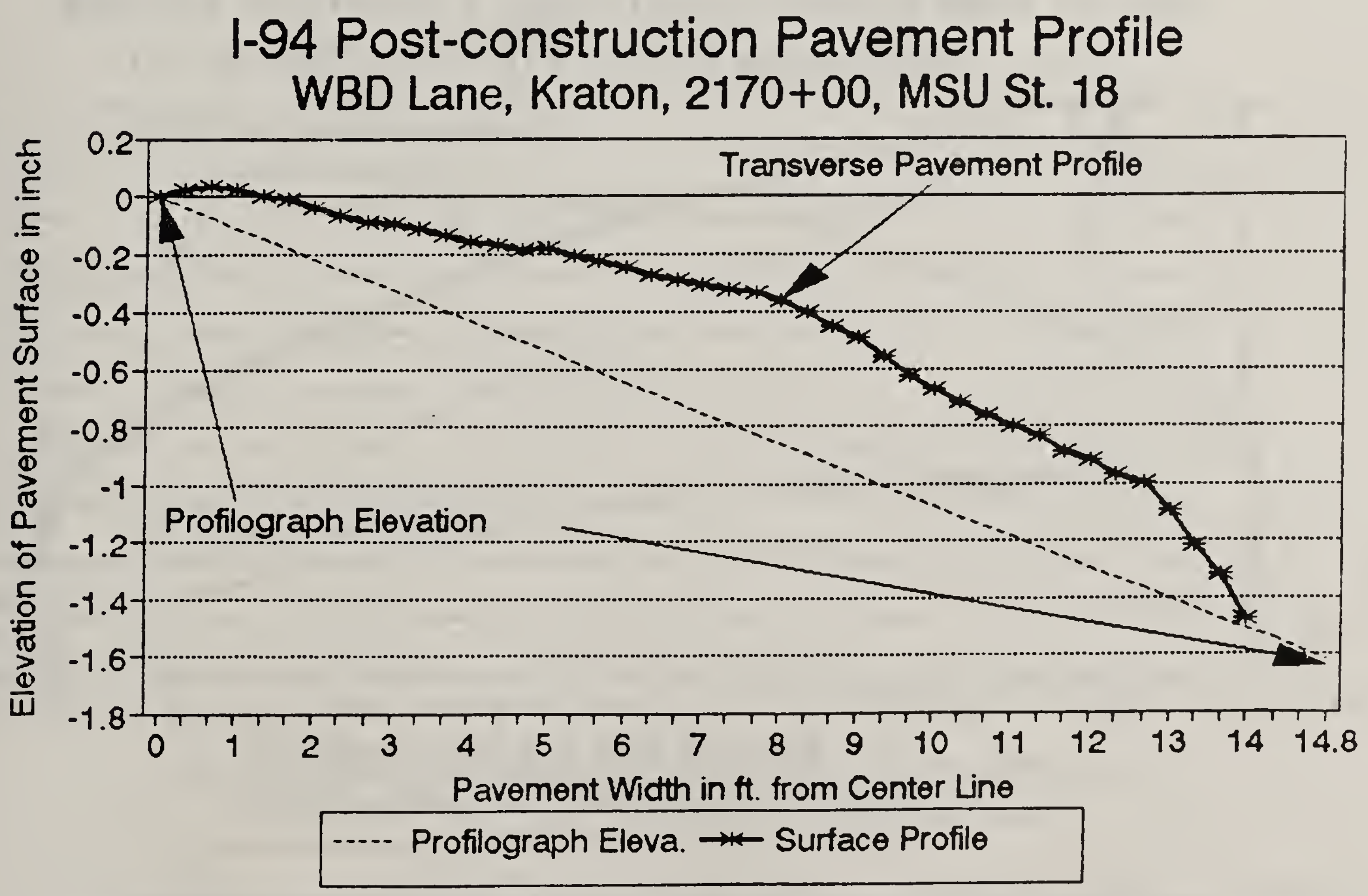
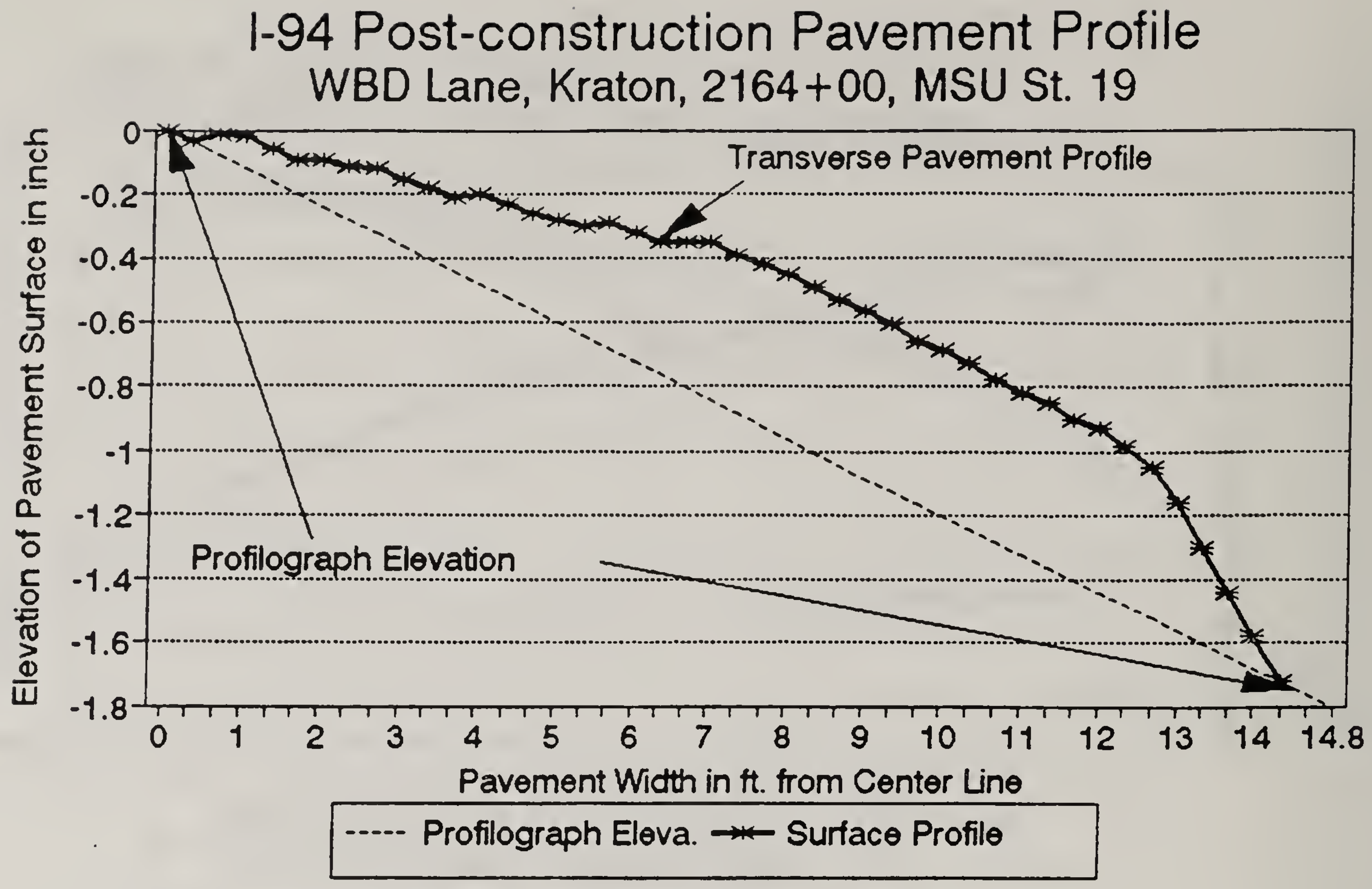


Fig. 9C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

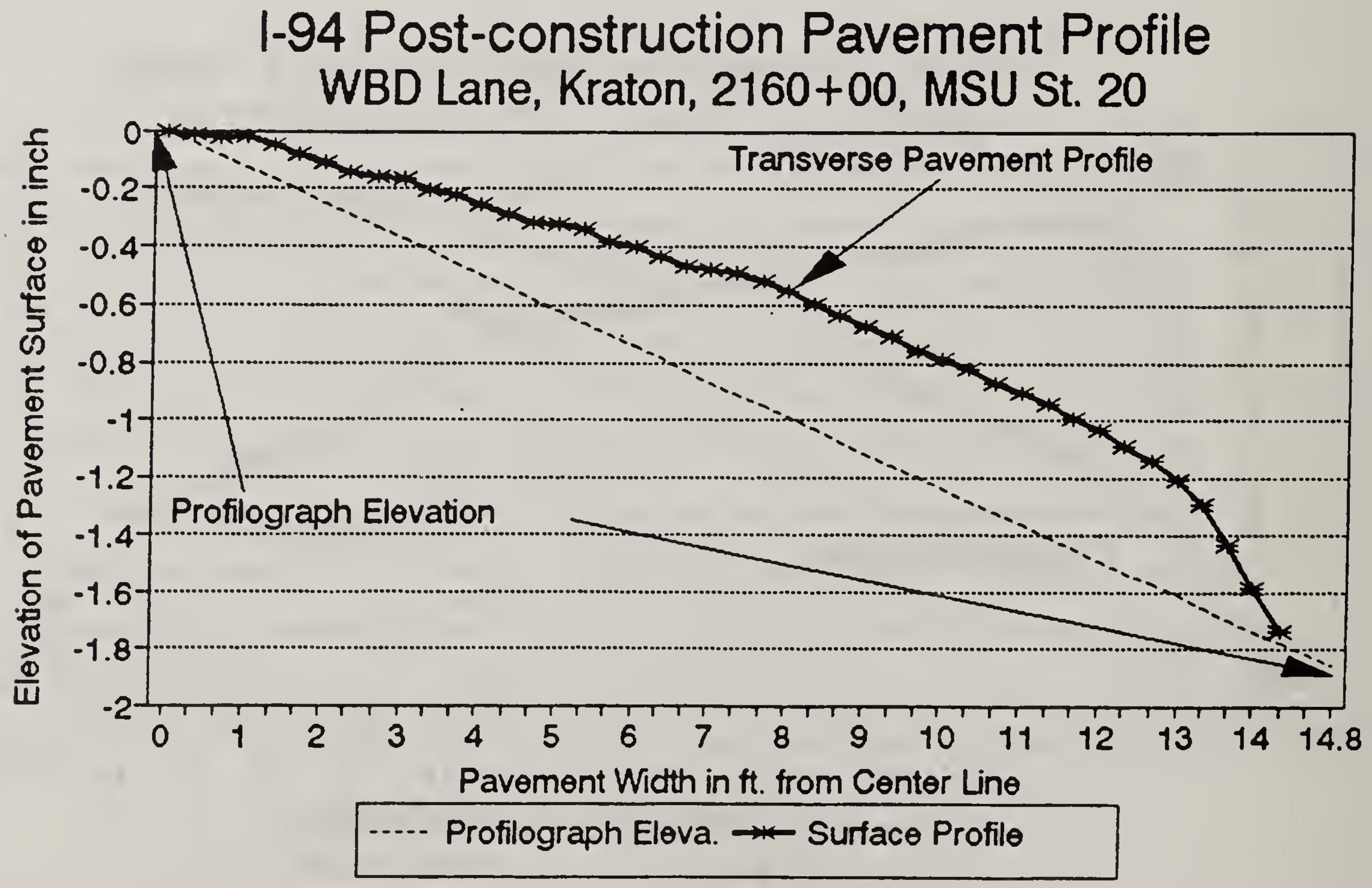
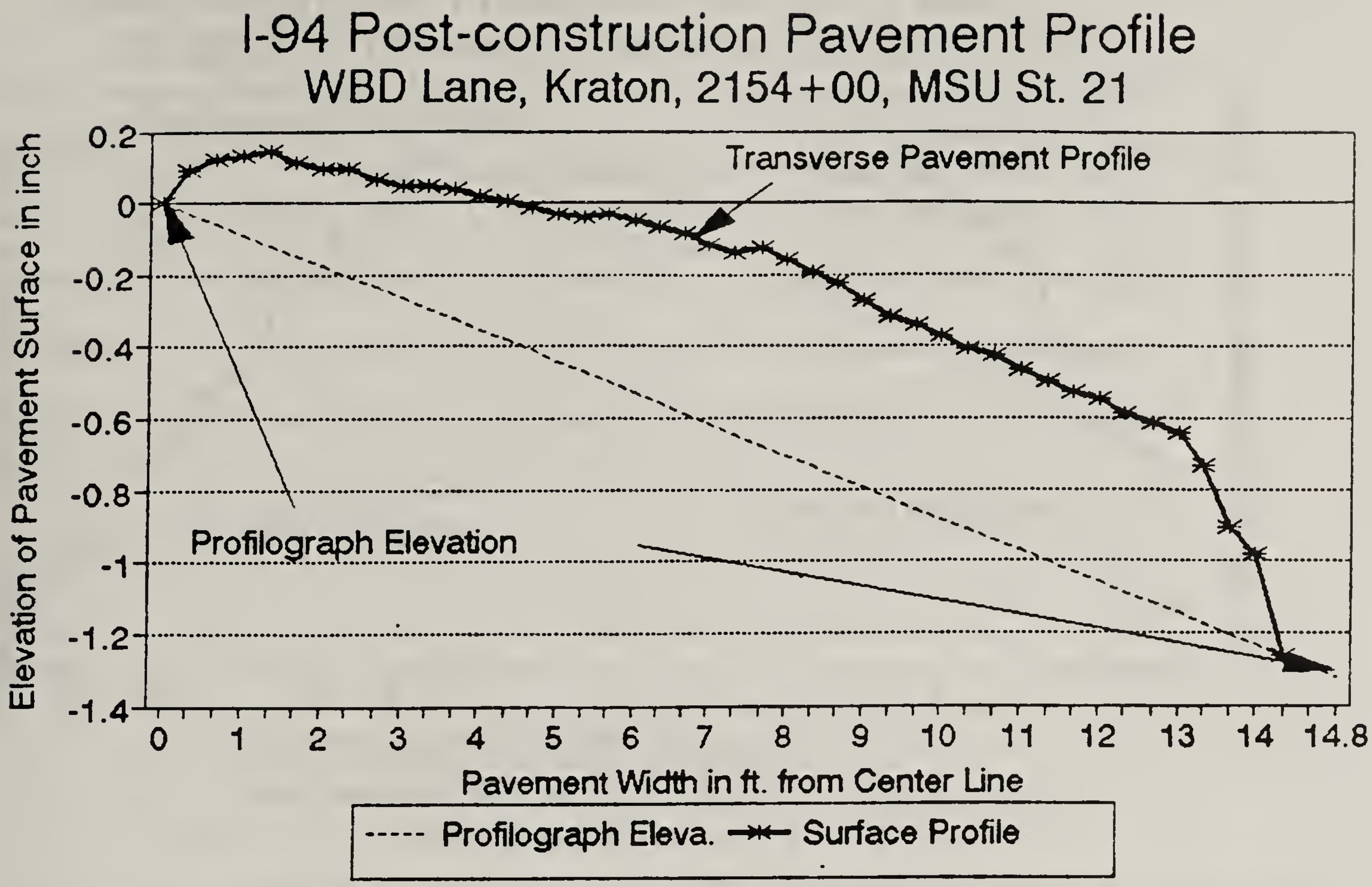


Fig. 10C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

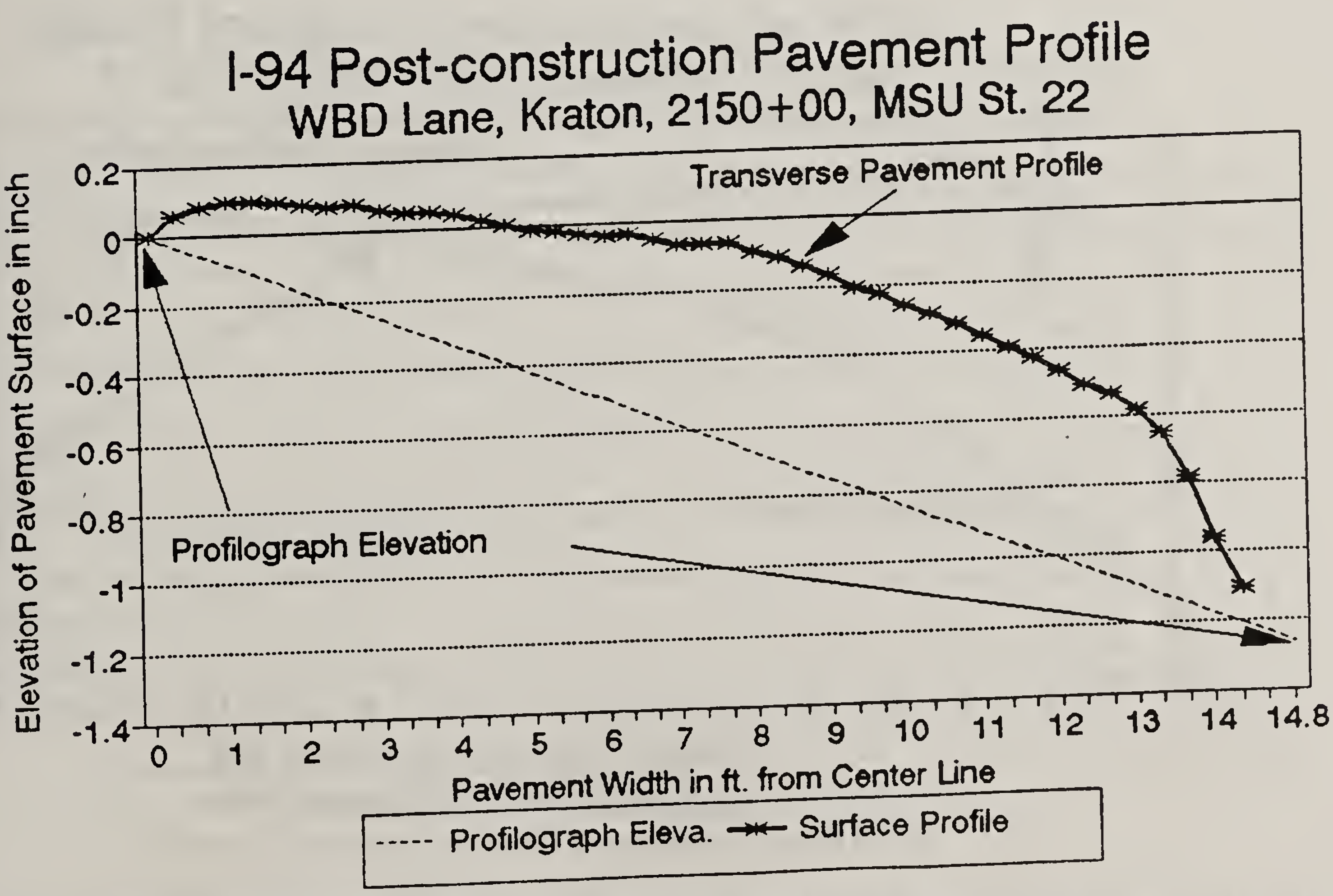
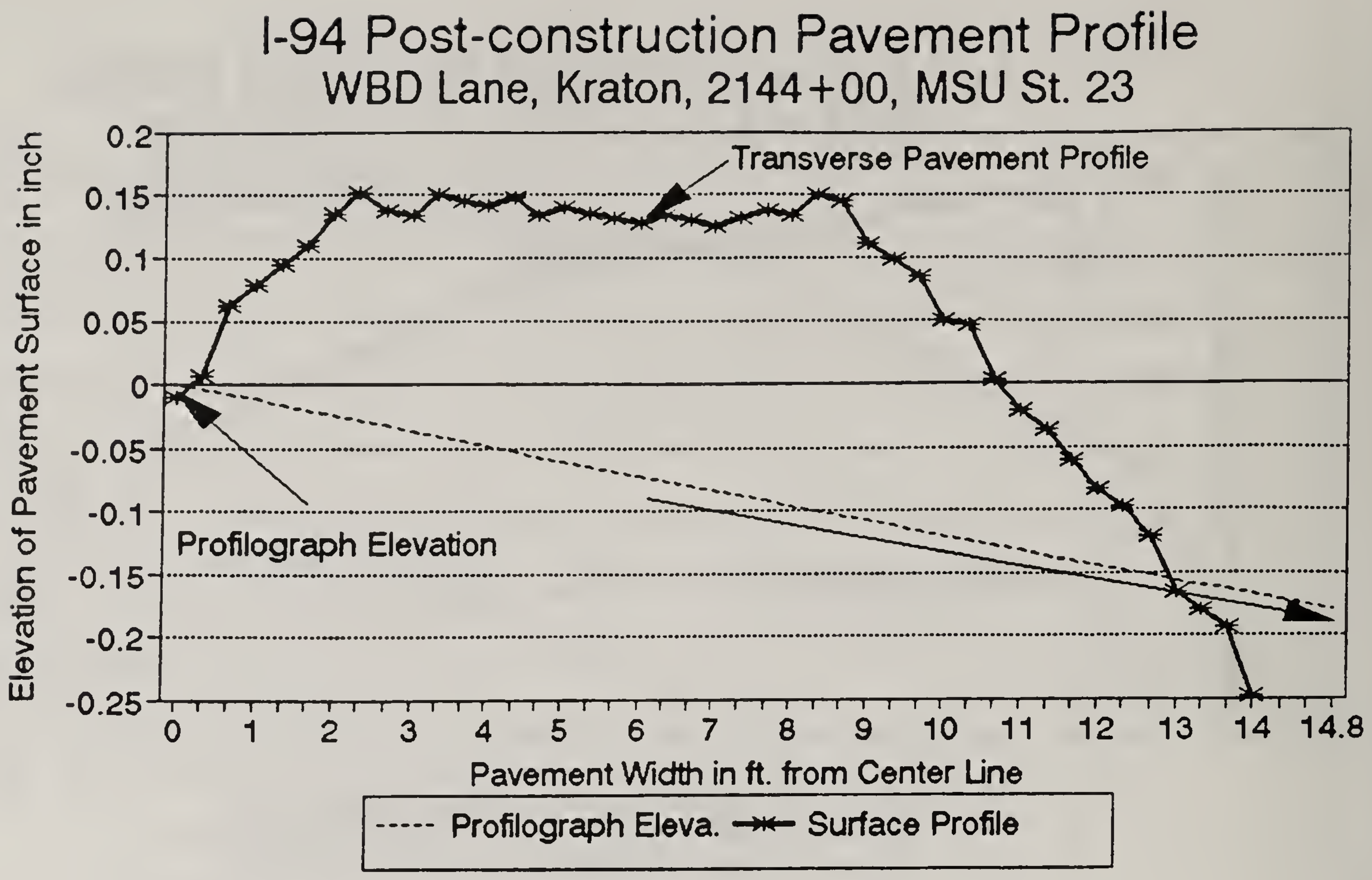


Fig. 11C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

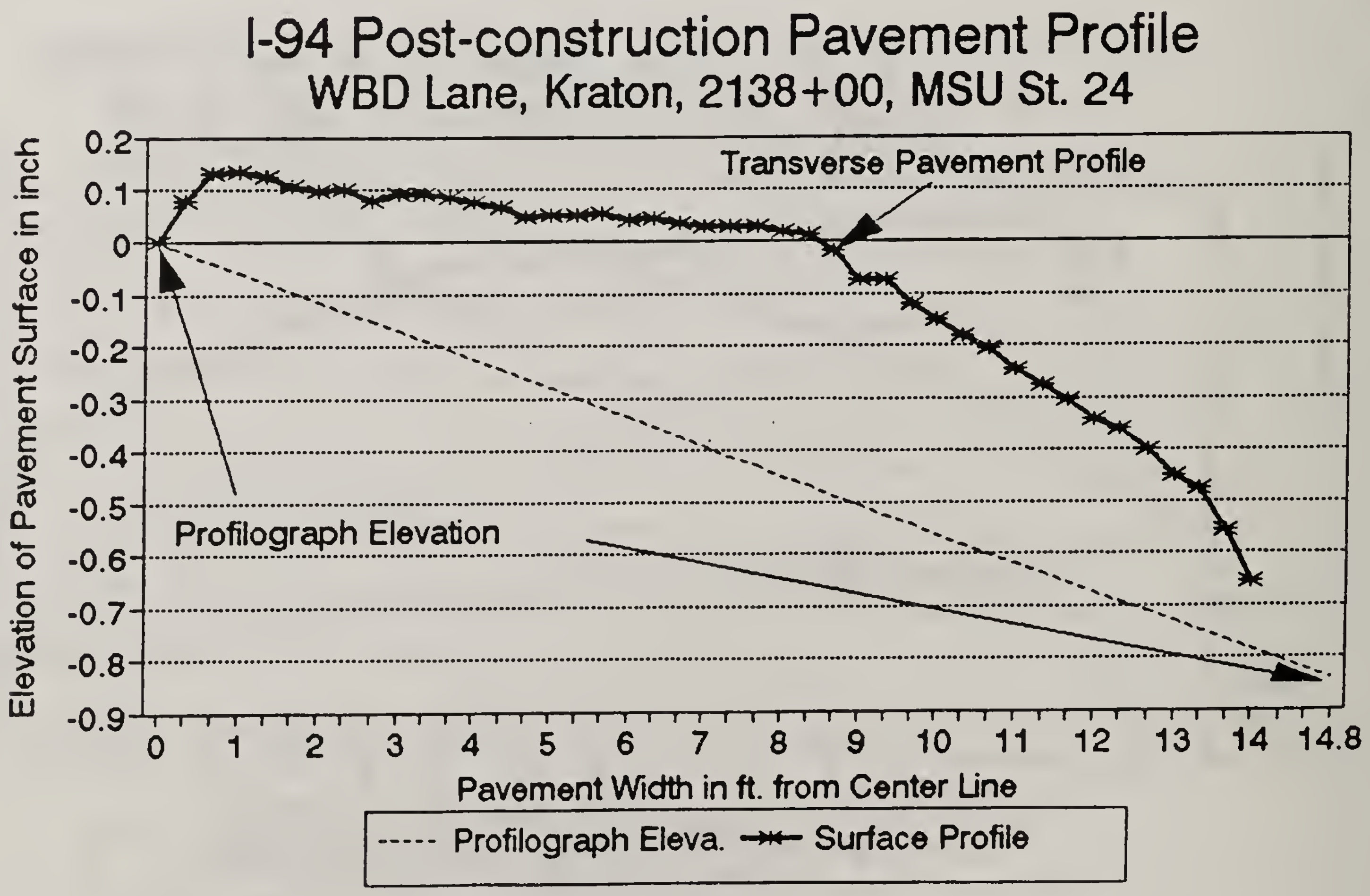
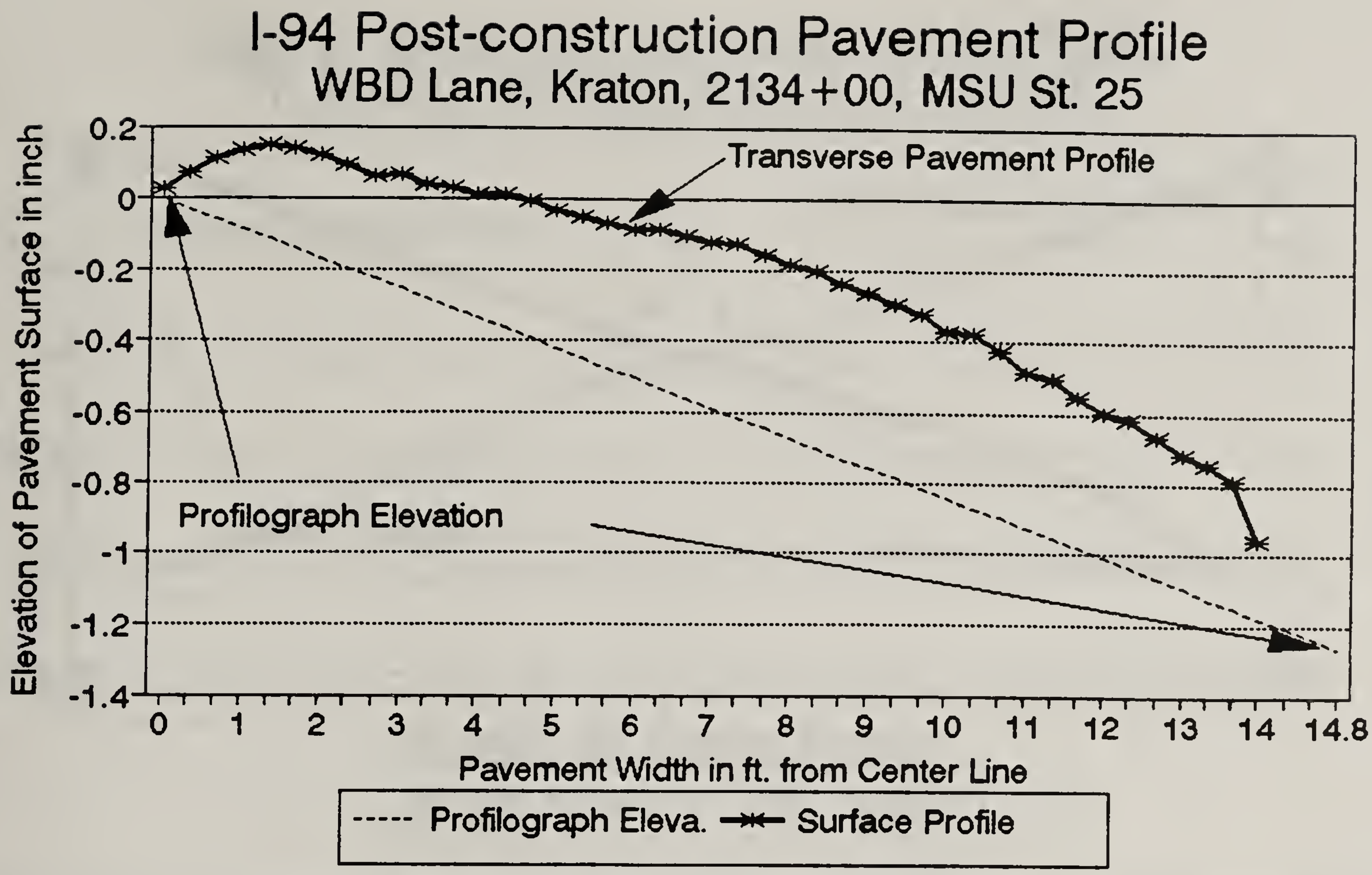


Fig. 12C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

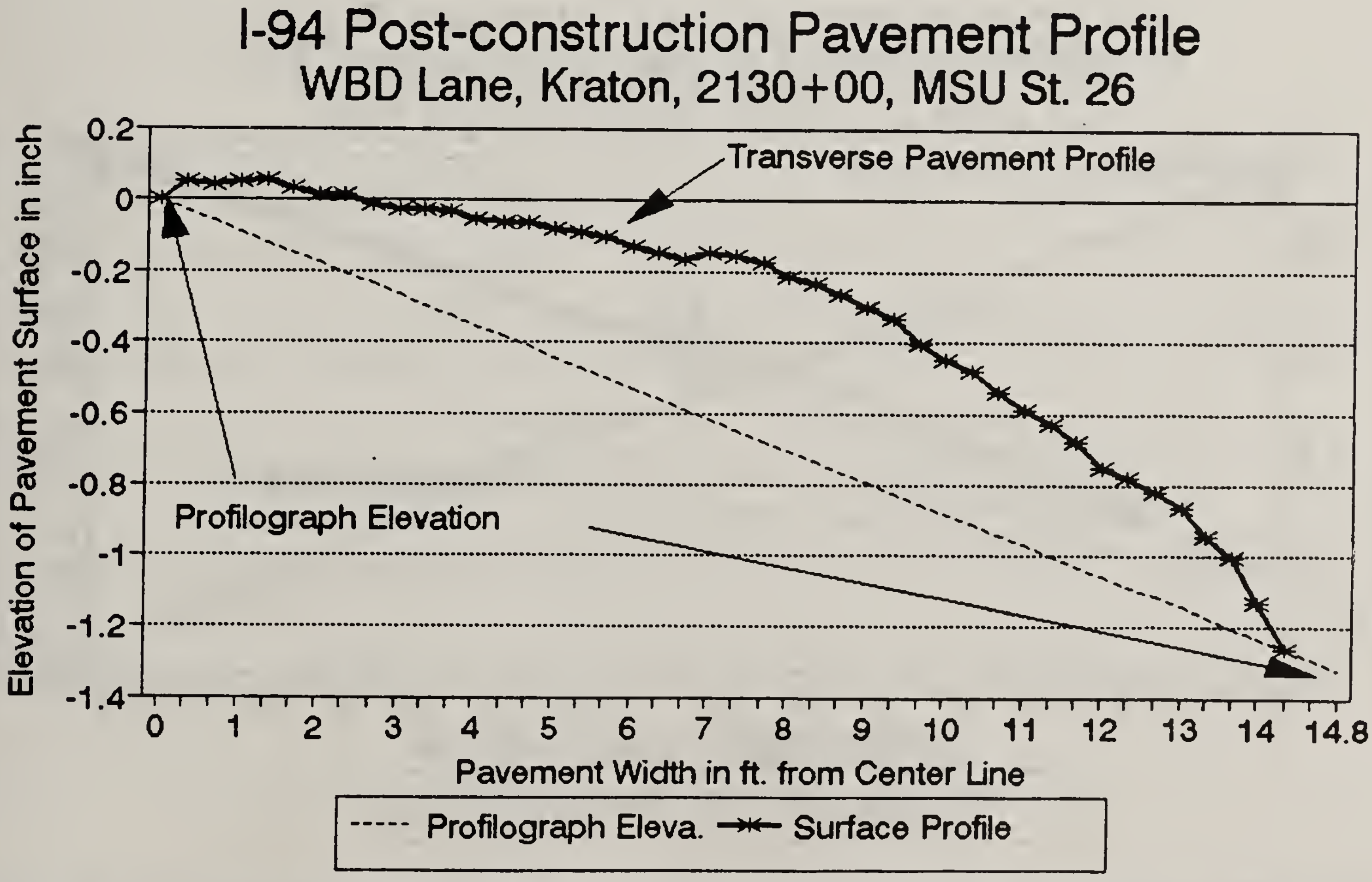
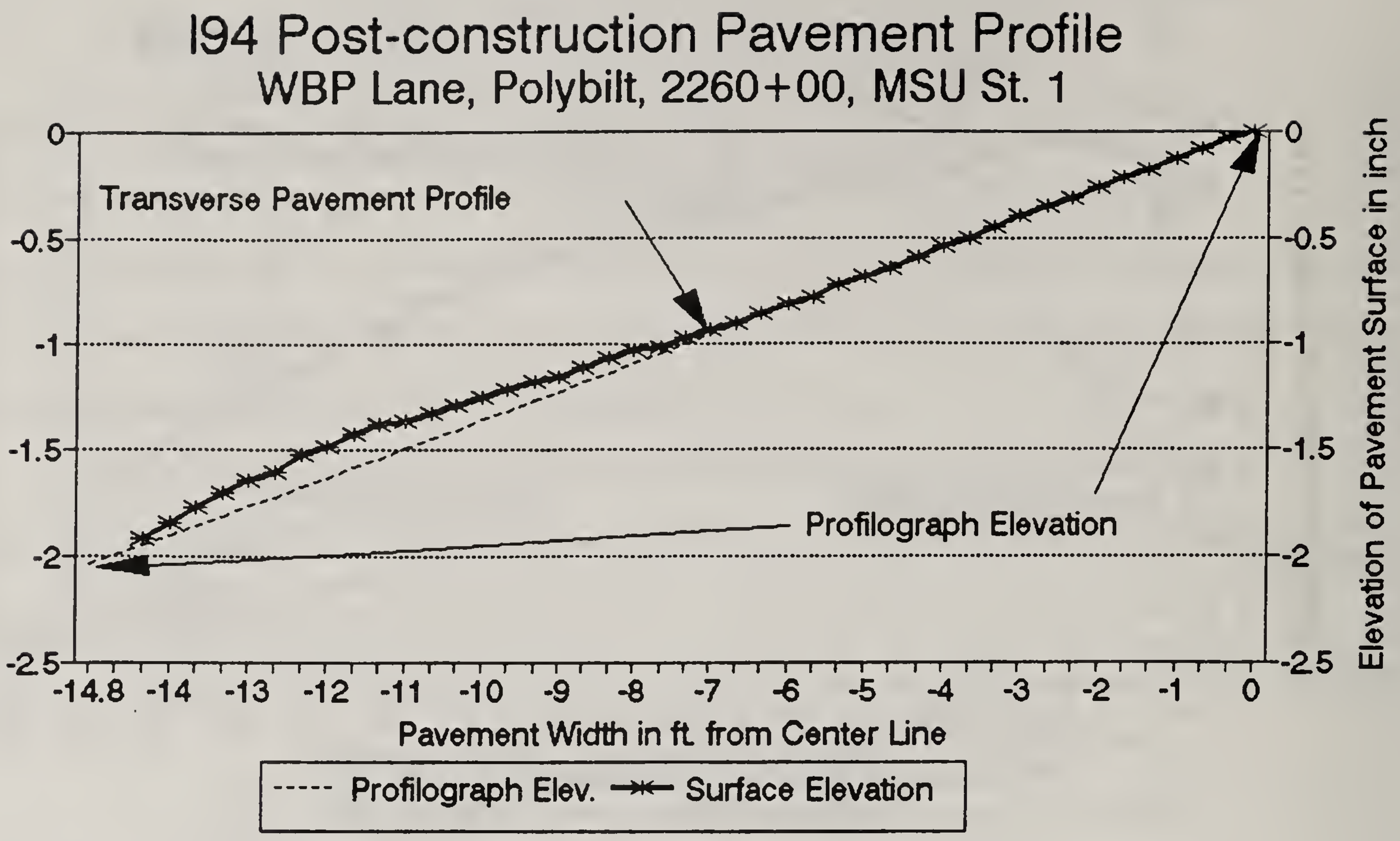


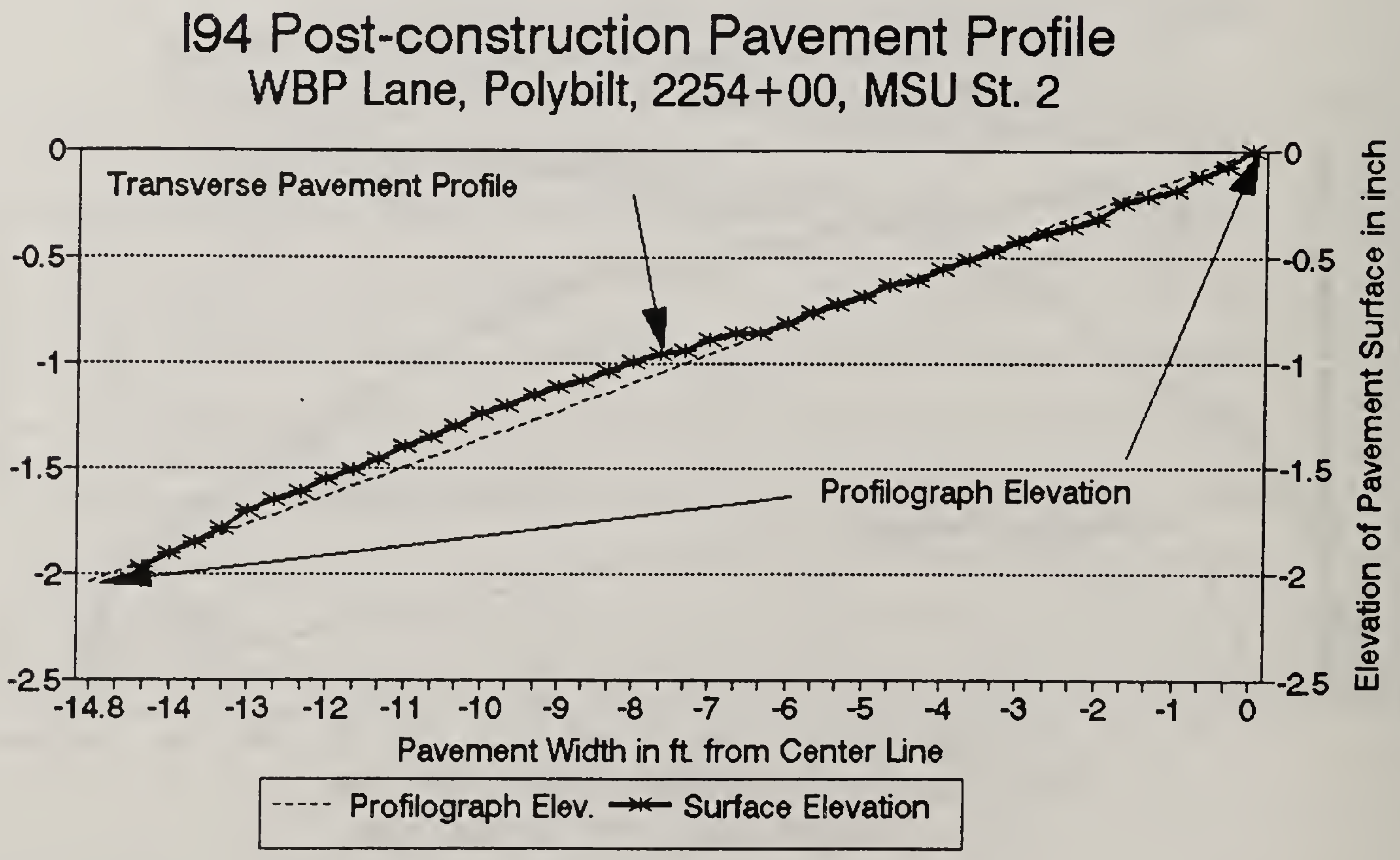
Fig. 13C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



I94 Post-construction Pavement Profile

WBP Lane, Polybilt, 2260+00, MSU St. 1

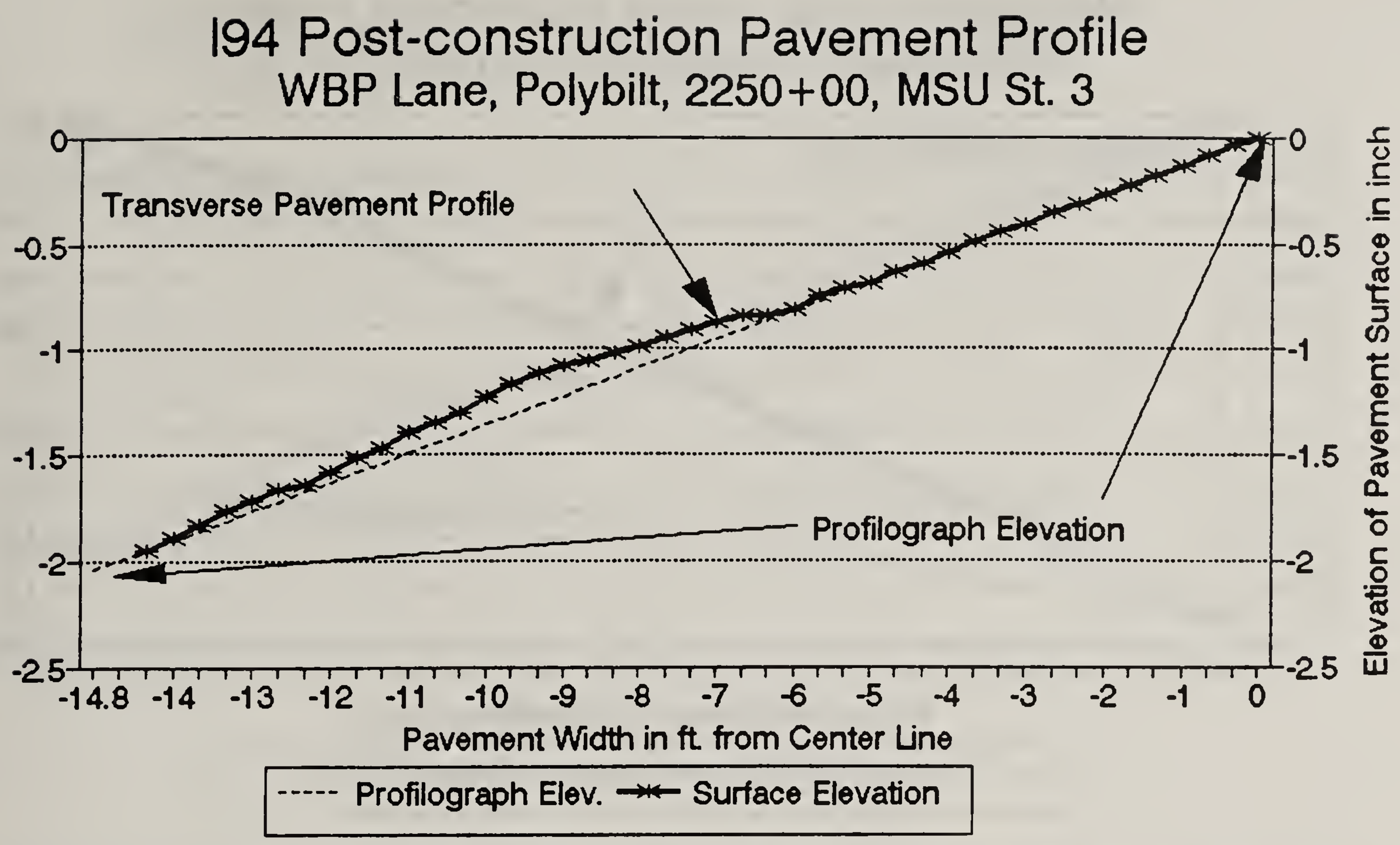
Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section



I94 Post-construction Pavement Profile

WBP Lane, Polybilt, 2254+00, MSU St. 2

Fig. 1D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section

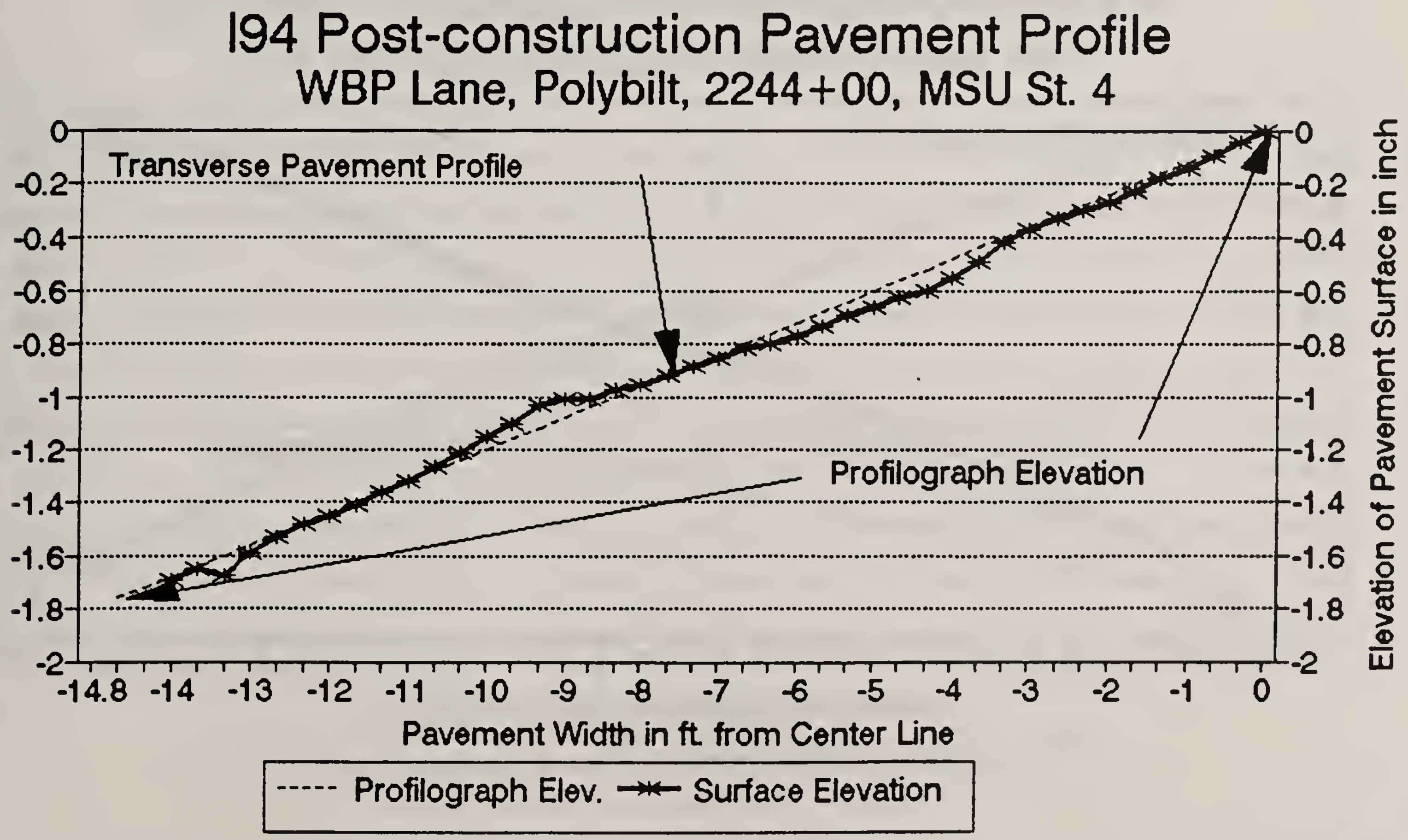
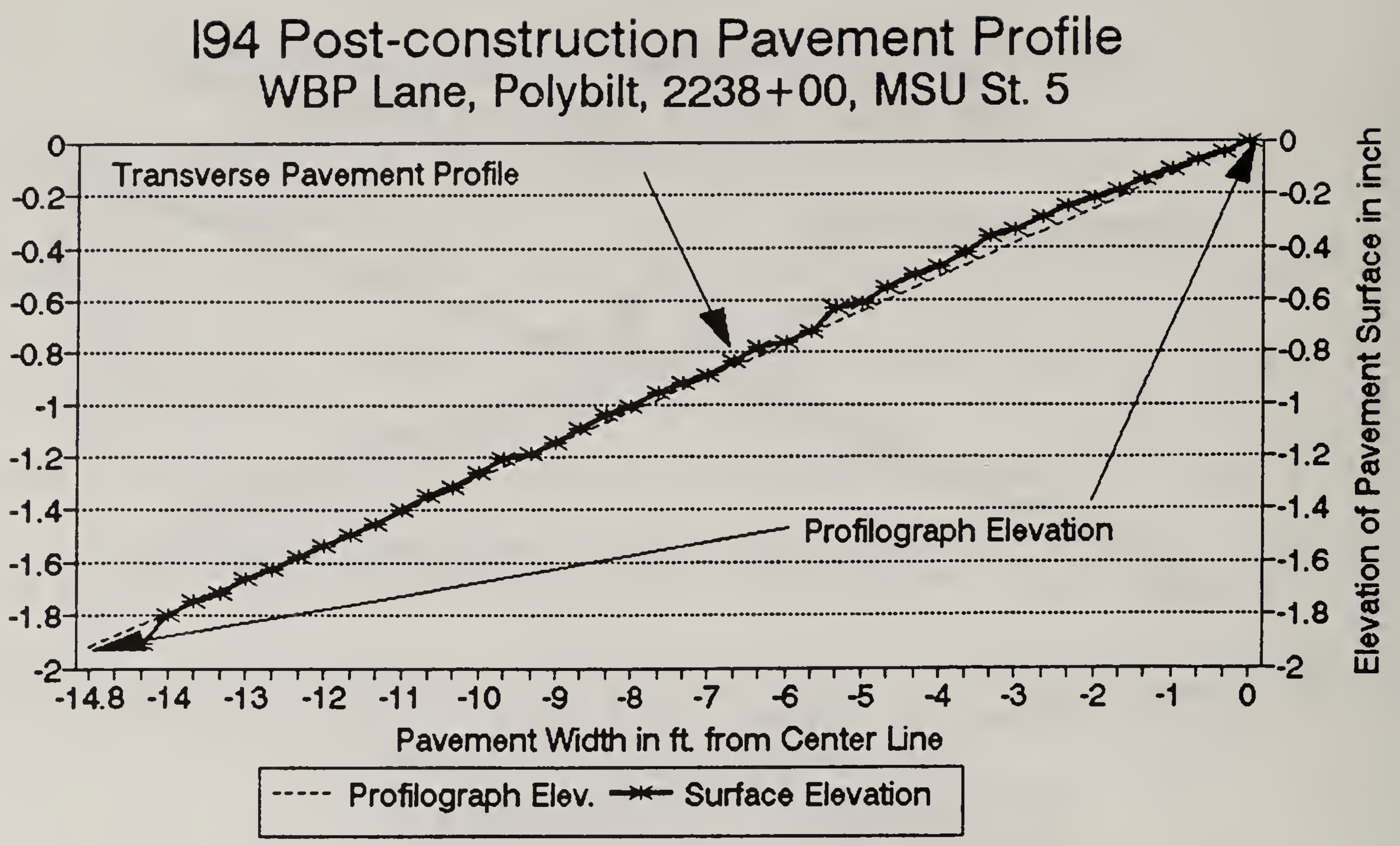


Fig. 2D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section

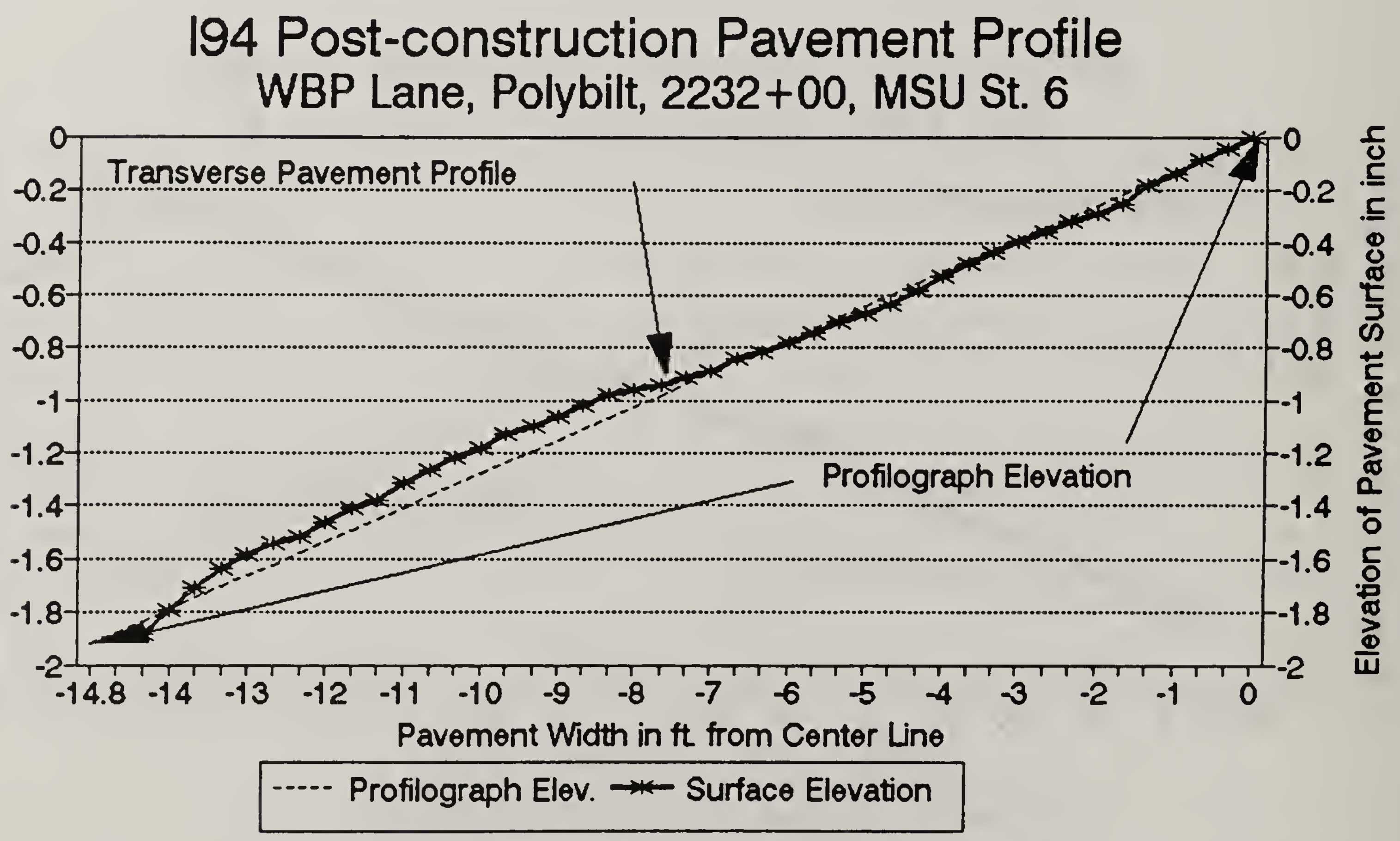
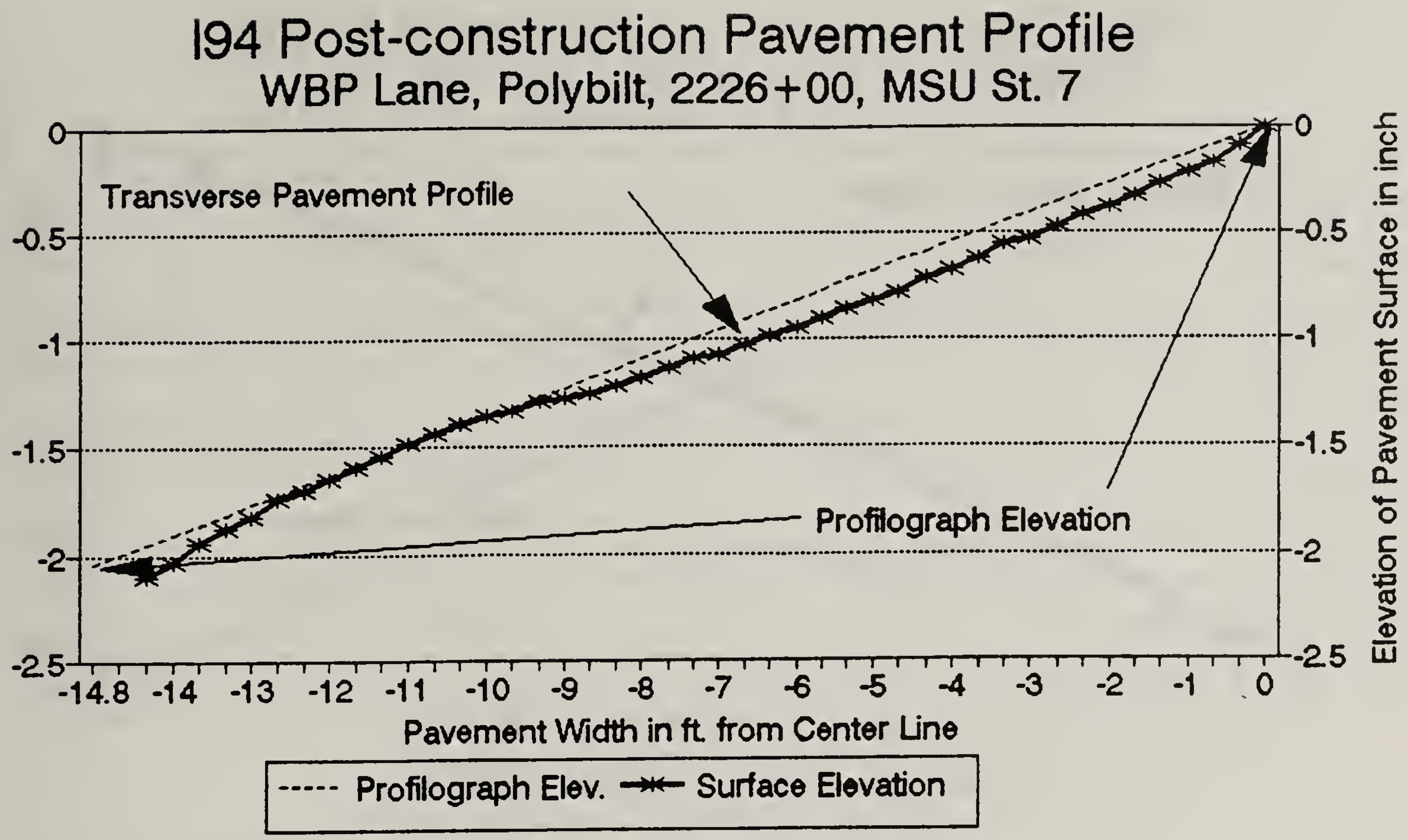


Fig. 3D. Post-construction Profile and Elevation, Center Line of Pavement as Origin


I94 Post-construction Pavement Profile
WBP Lane, Polybilt, 2226+00, MSU St. 7

Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section

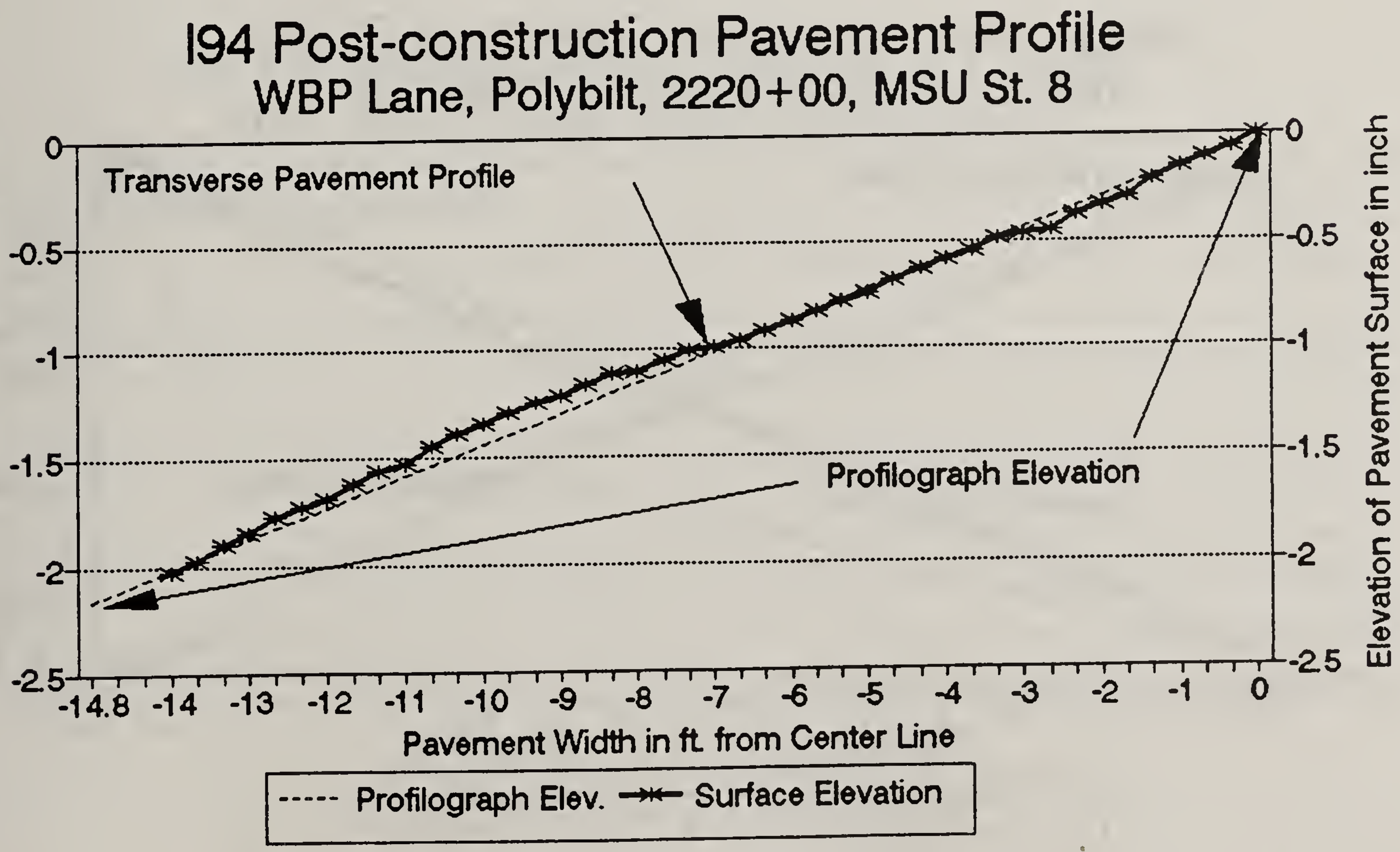
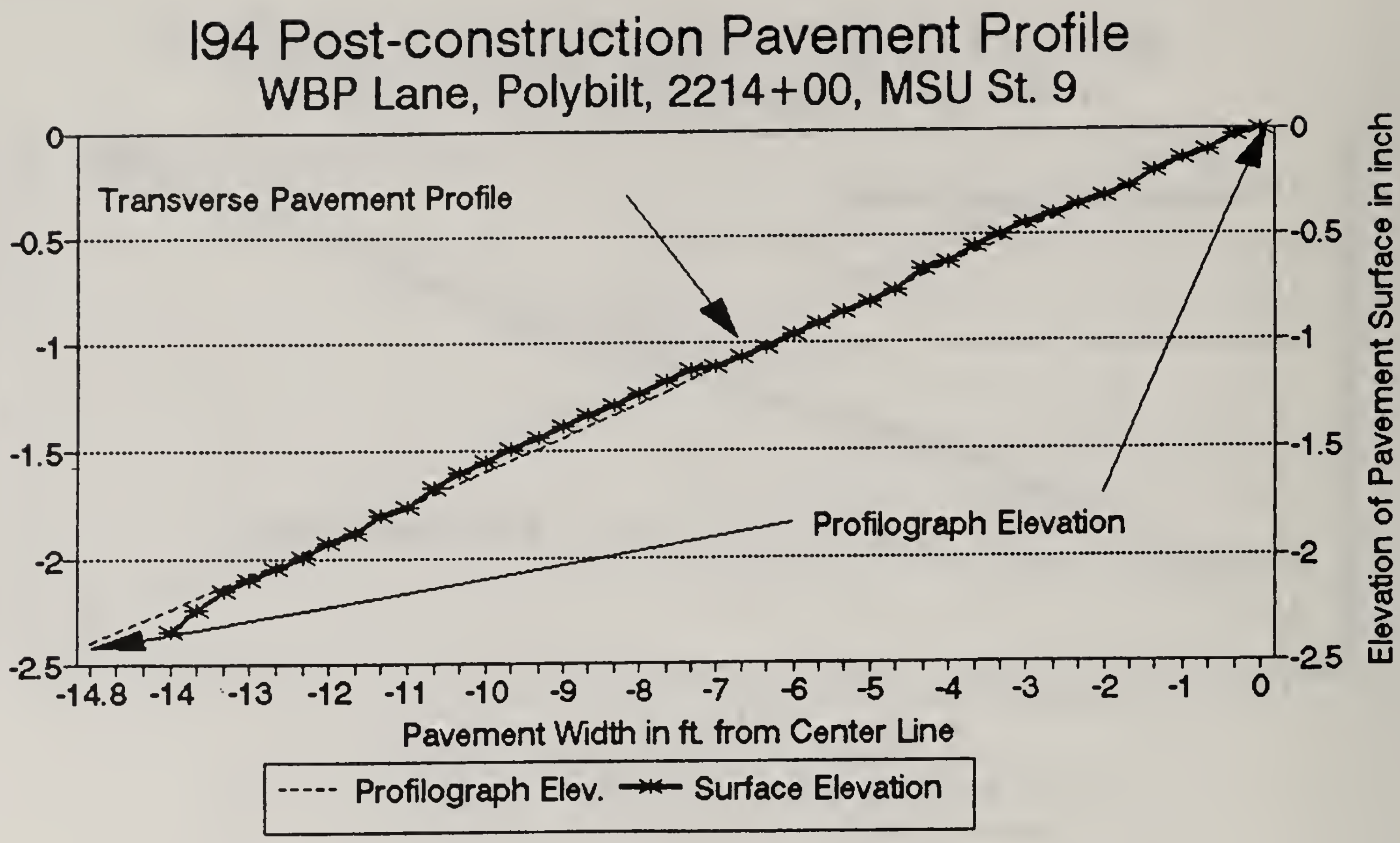

I94 Post-construction Pavement Profile
WBP Lane, Polybilt, 2220+00, MSU St. 8

Fig. 4D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Polybilt Modified Binder Section

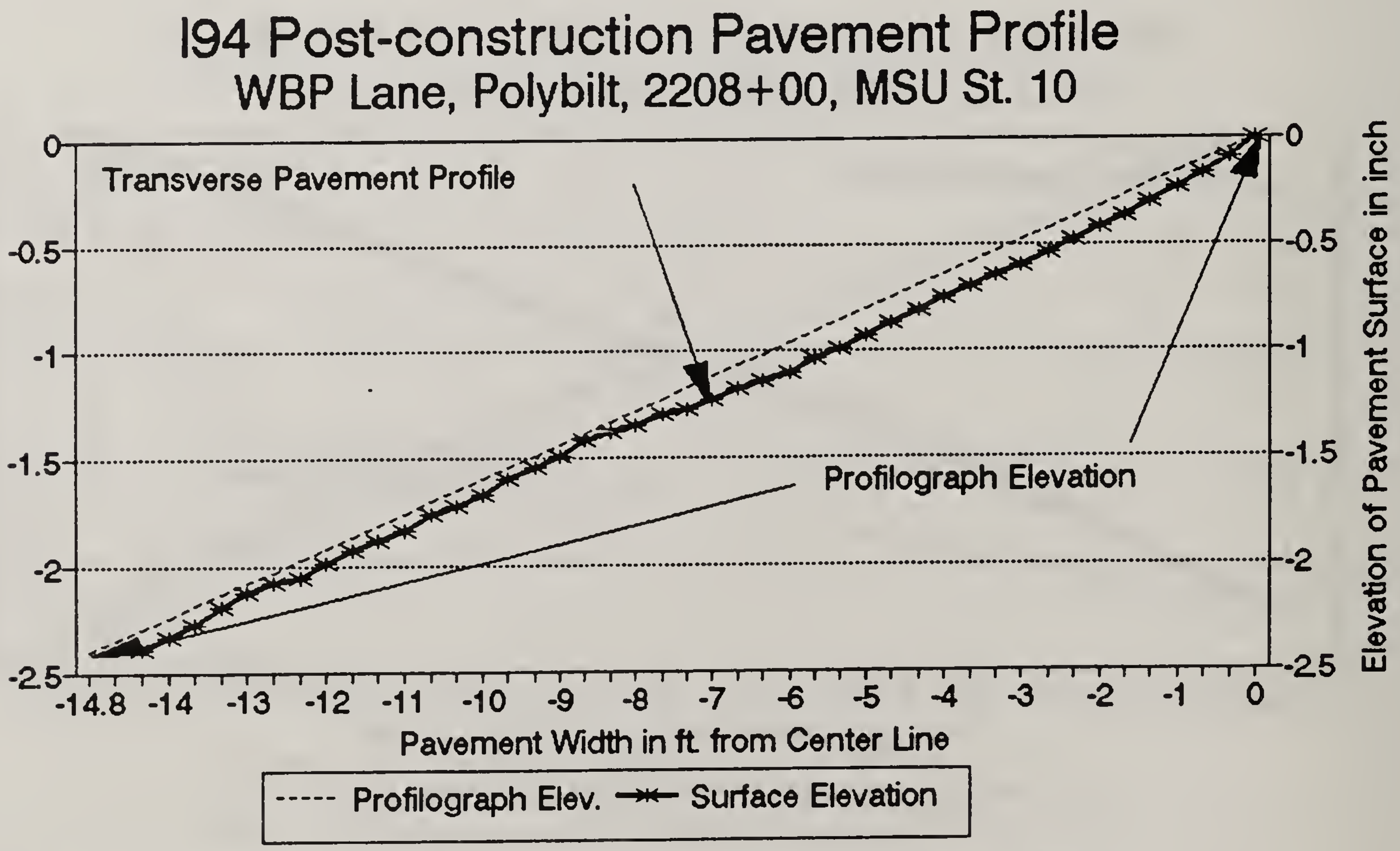
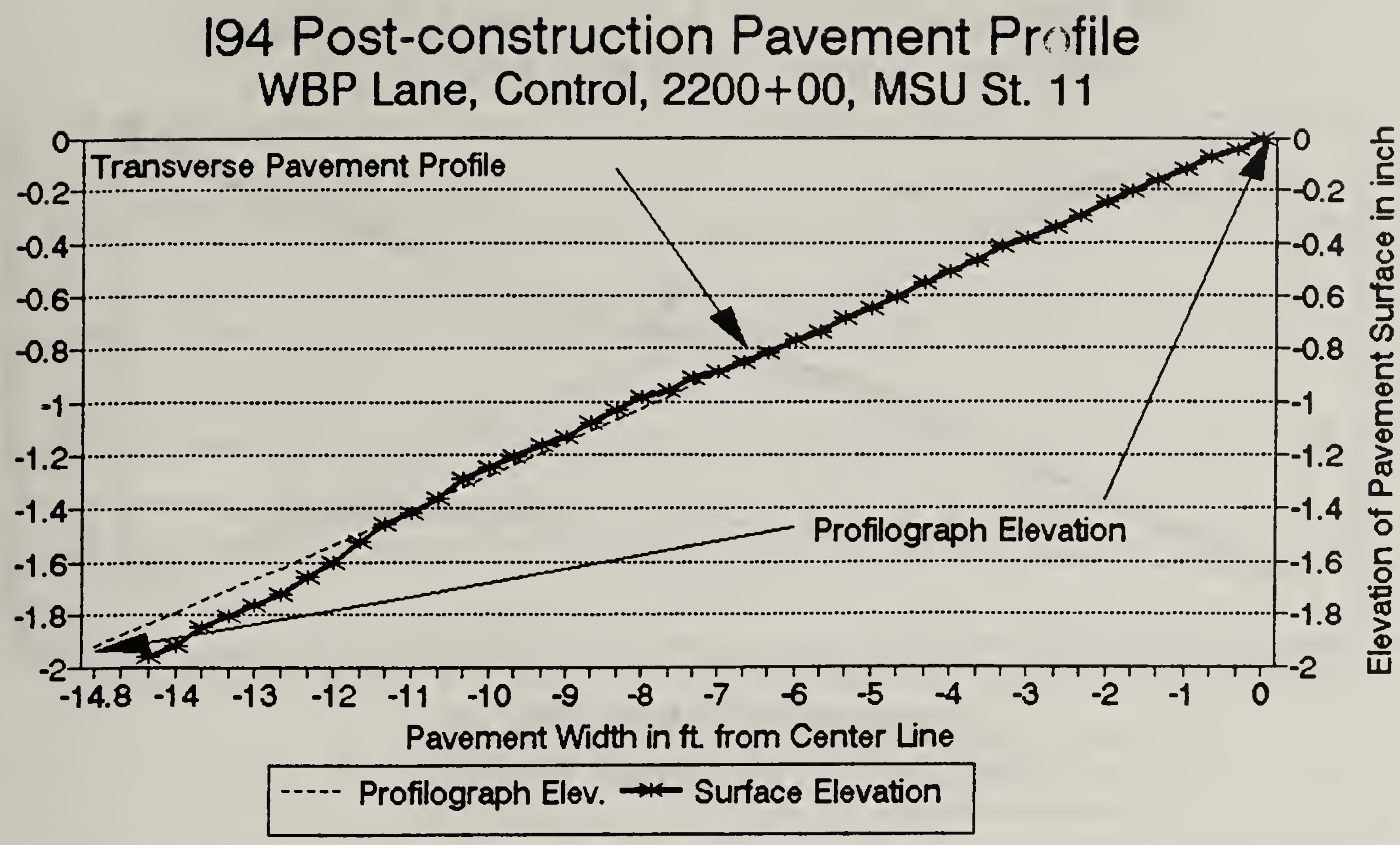


Fig. 5D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

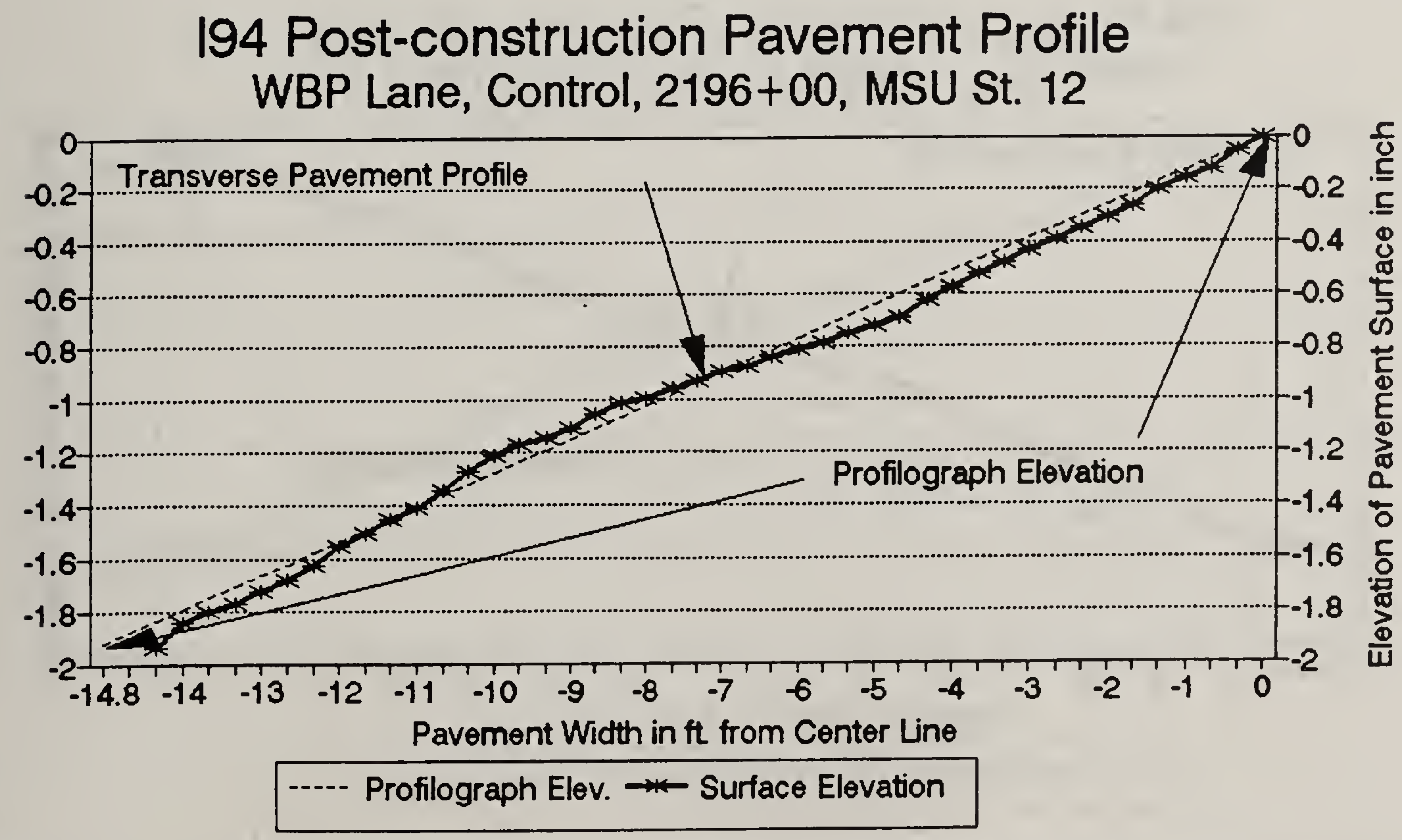
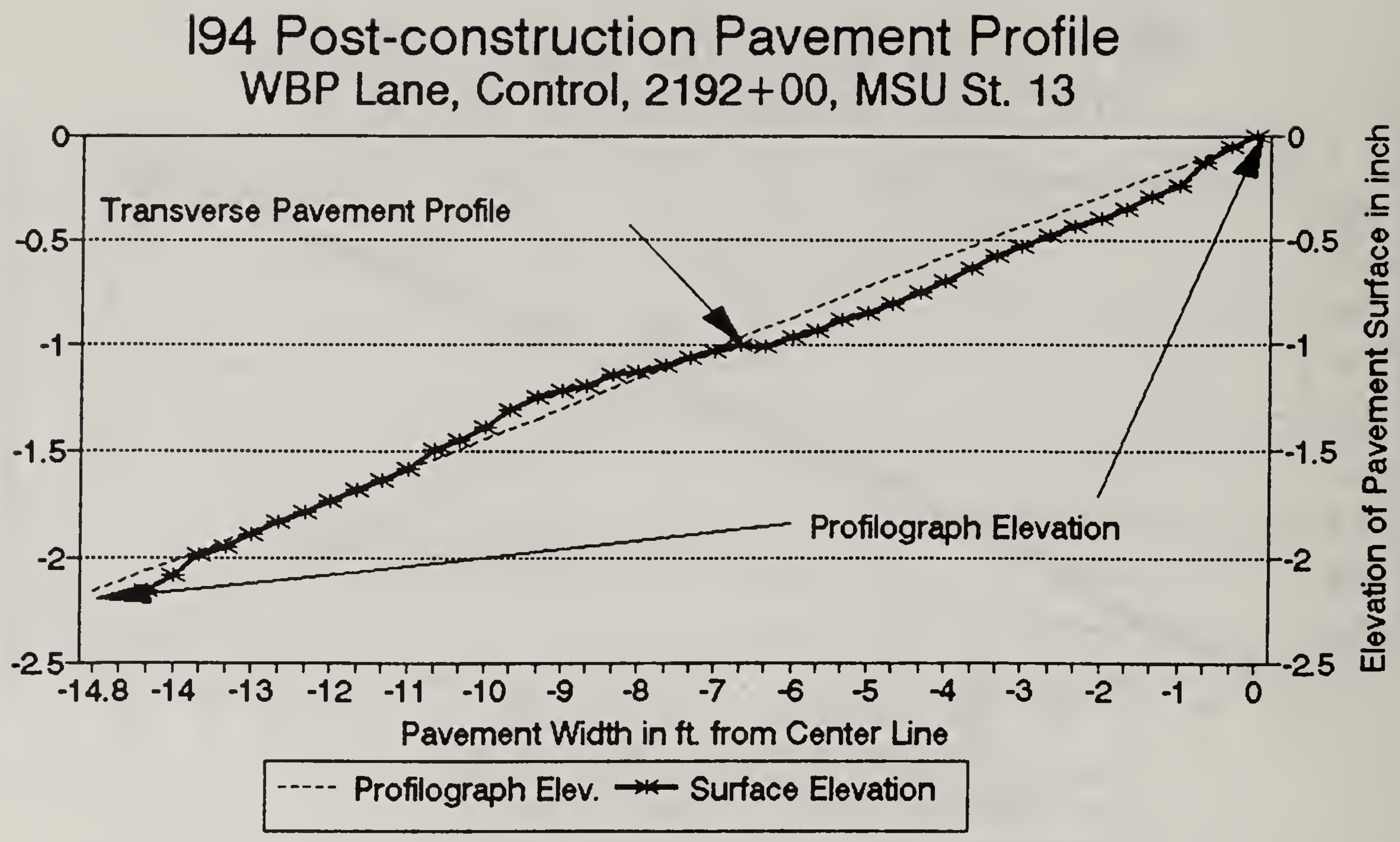


Fig. 6D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

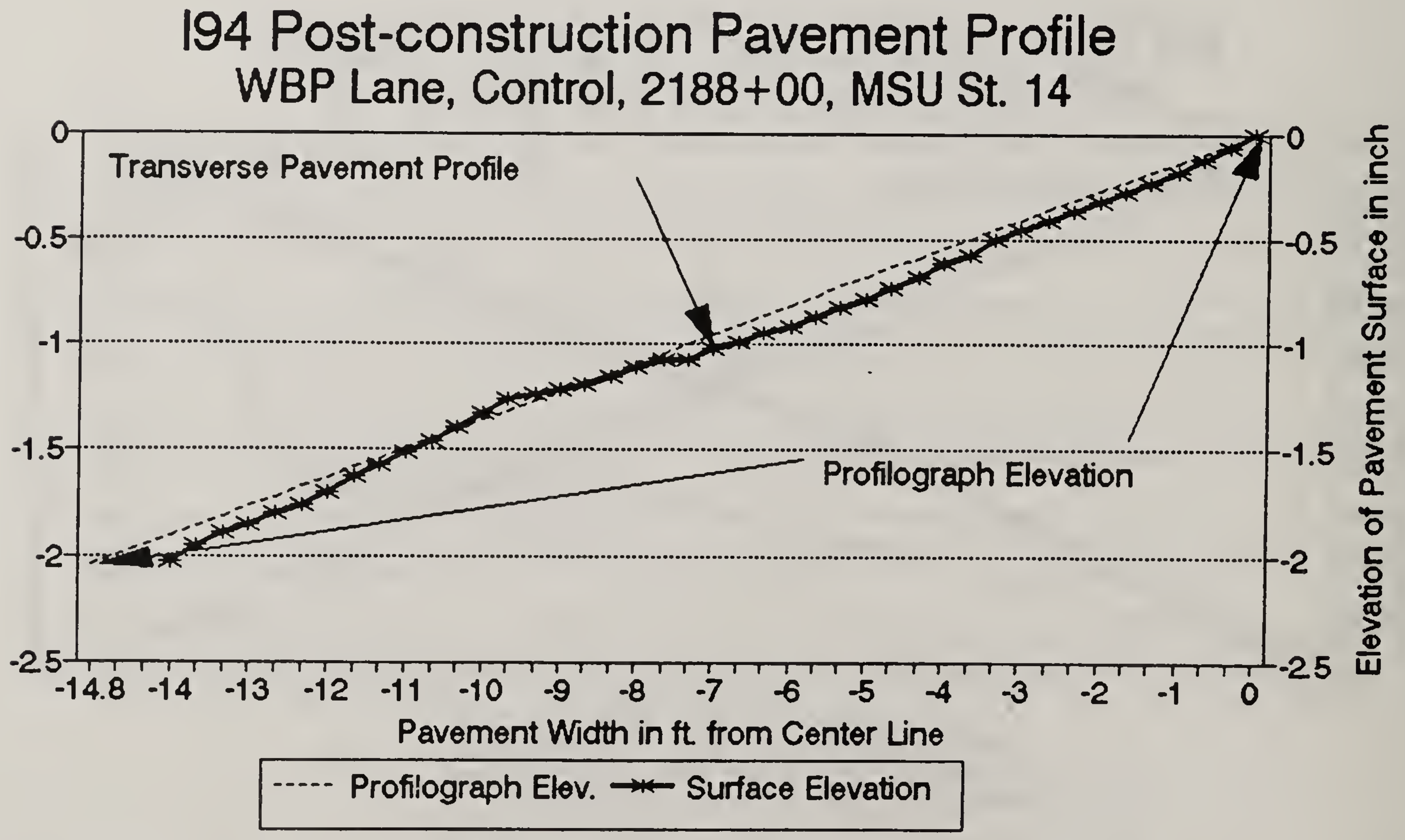
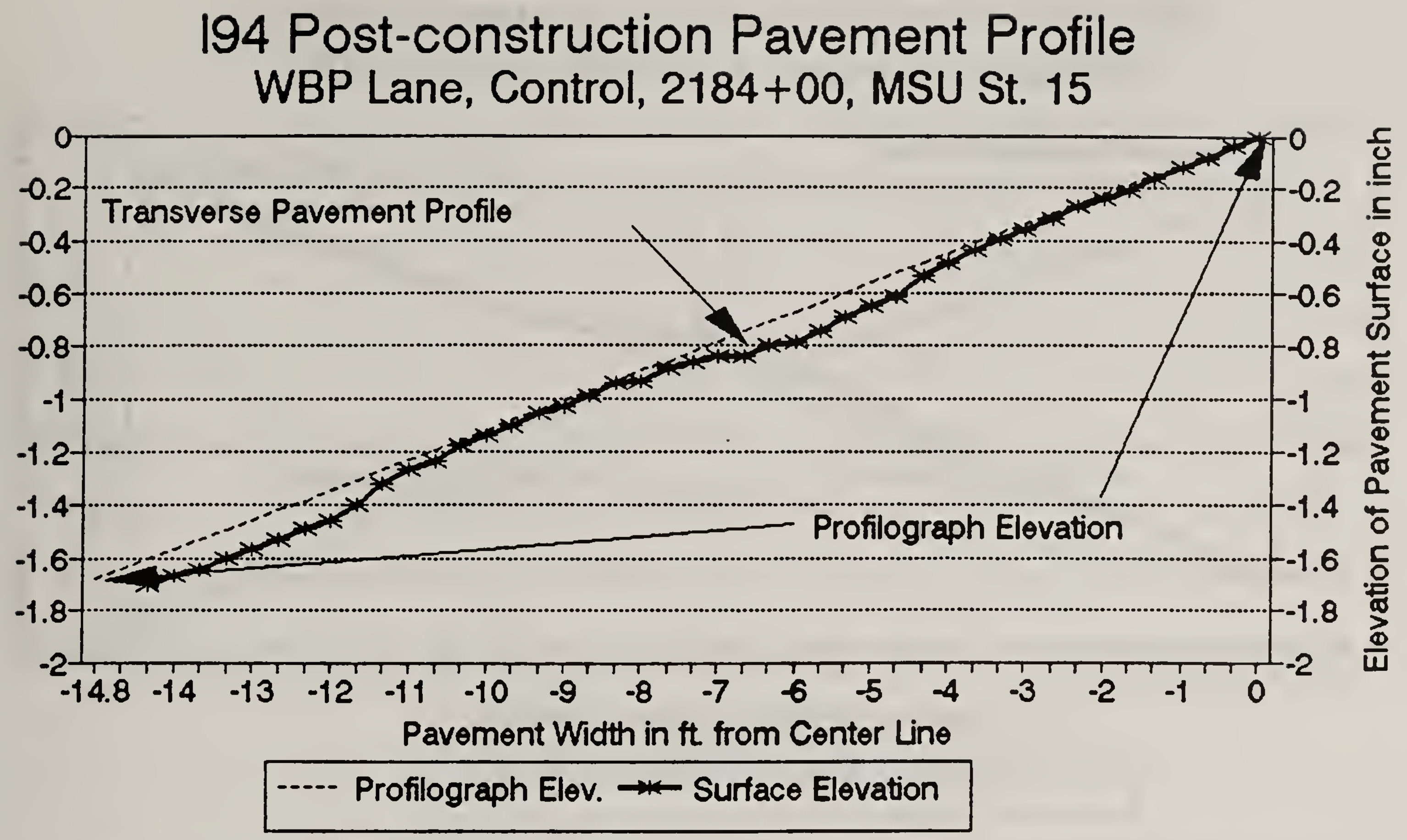


Fig. 7D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

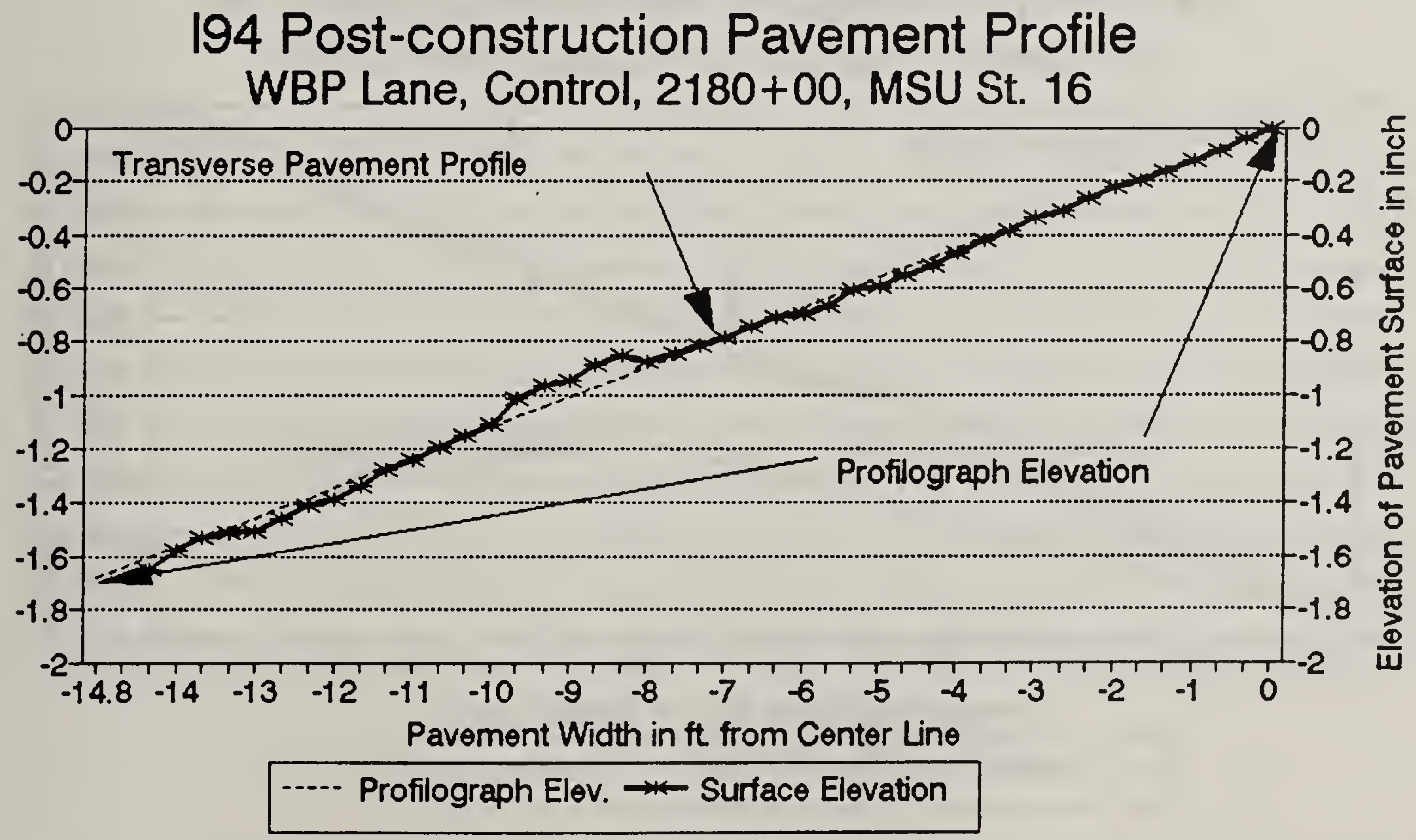
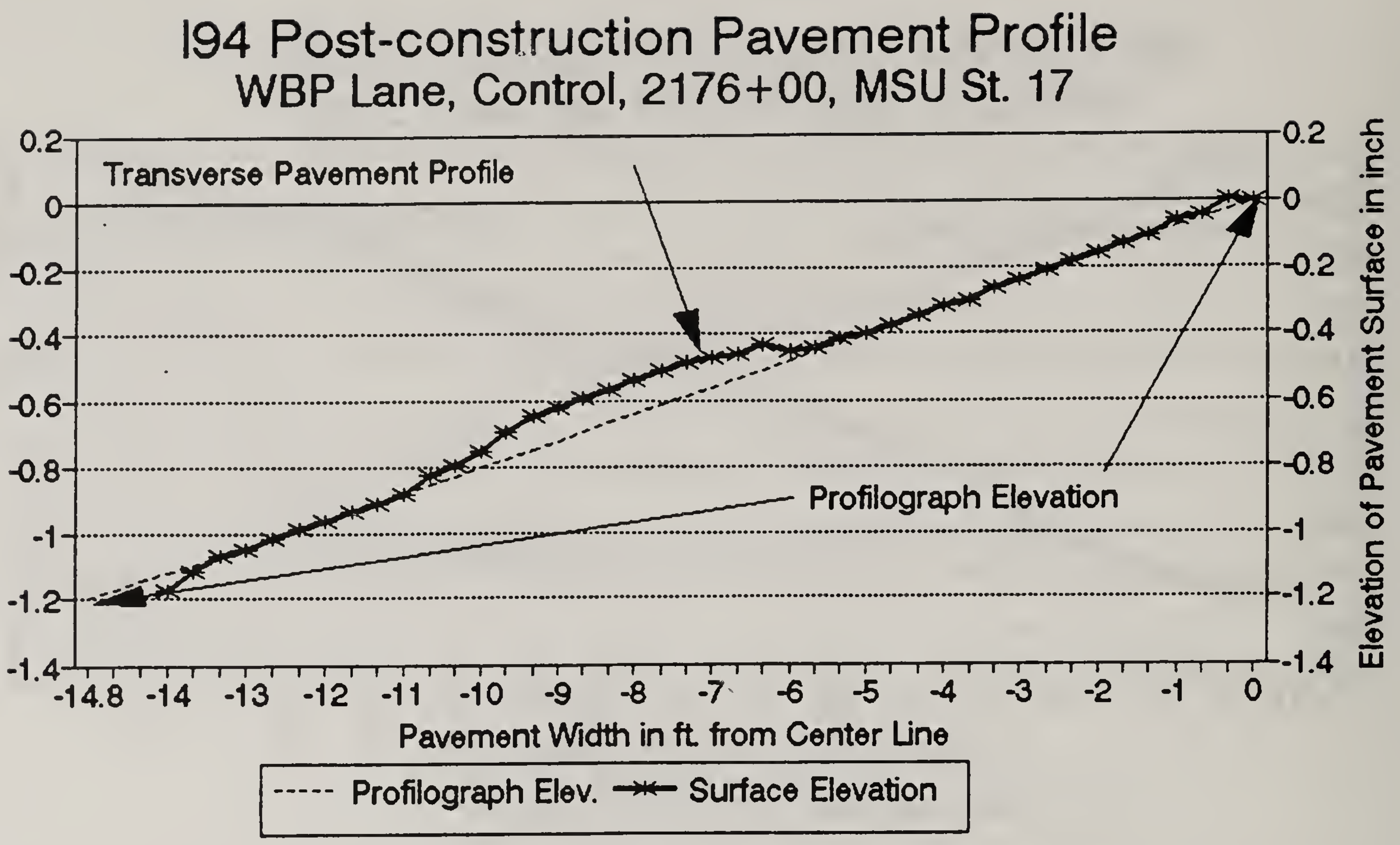


Fig. 8D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Passing (WBP) Lane, Control Section - Unmodified Exxon

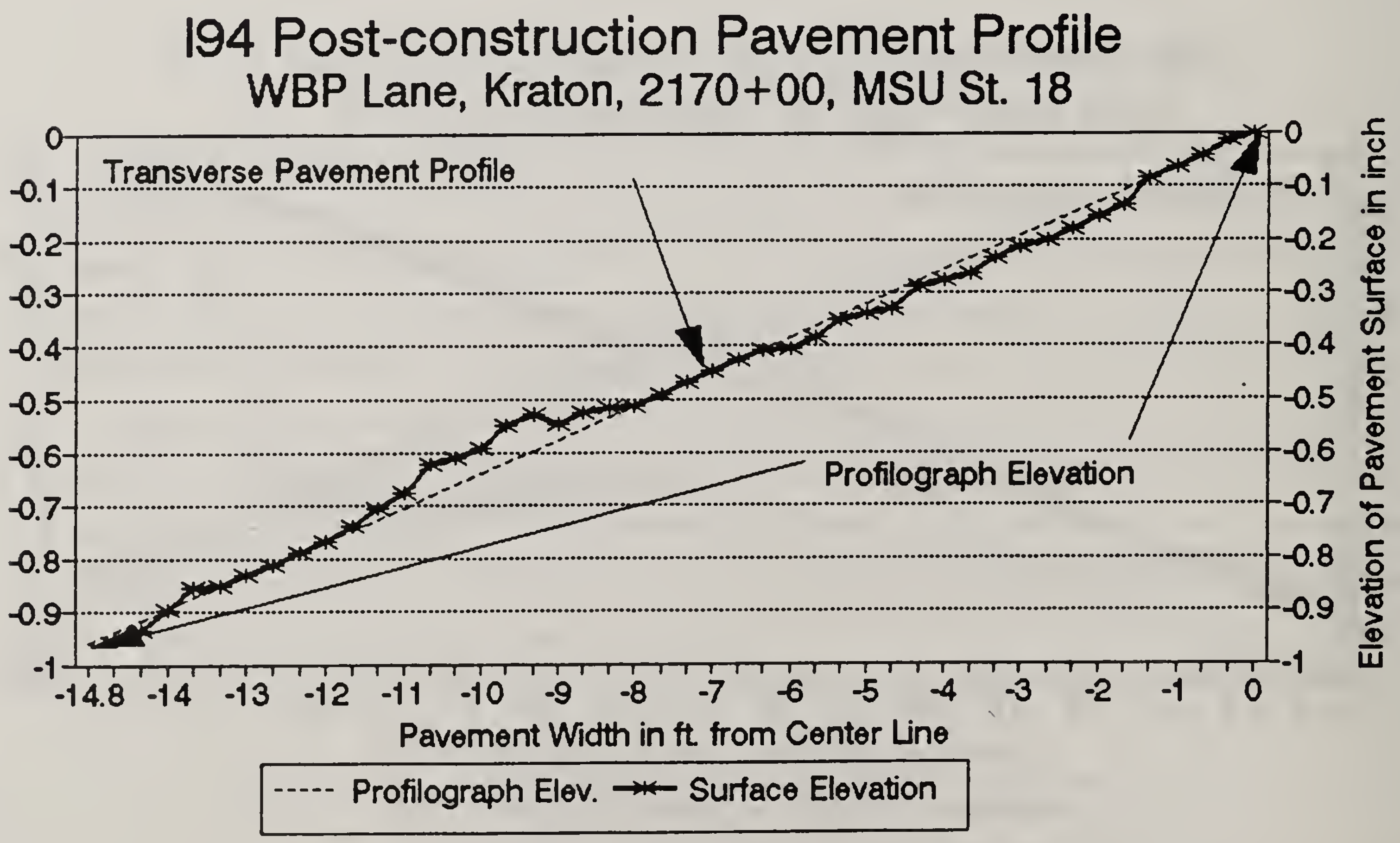
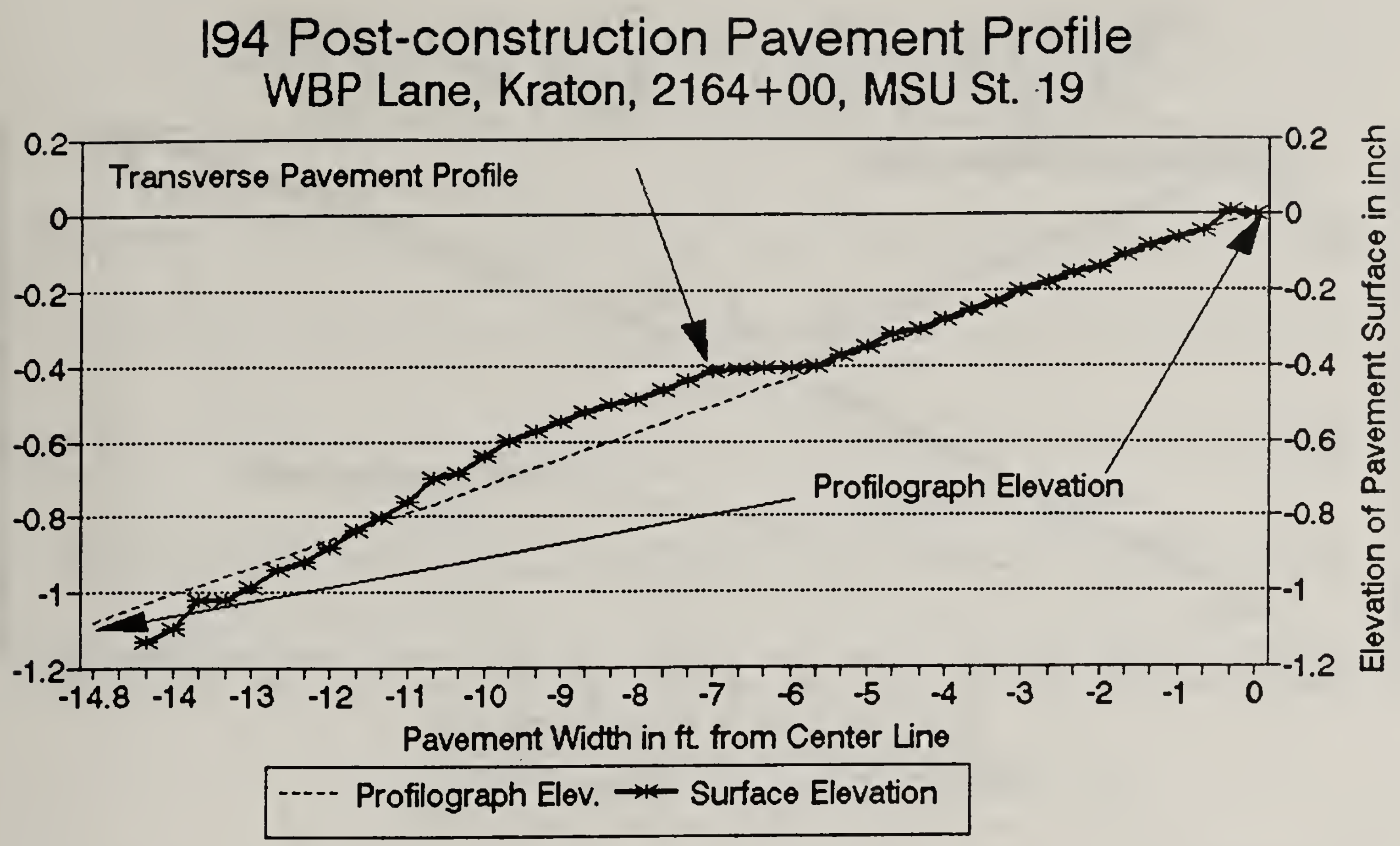


Fig. 9D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

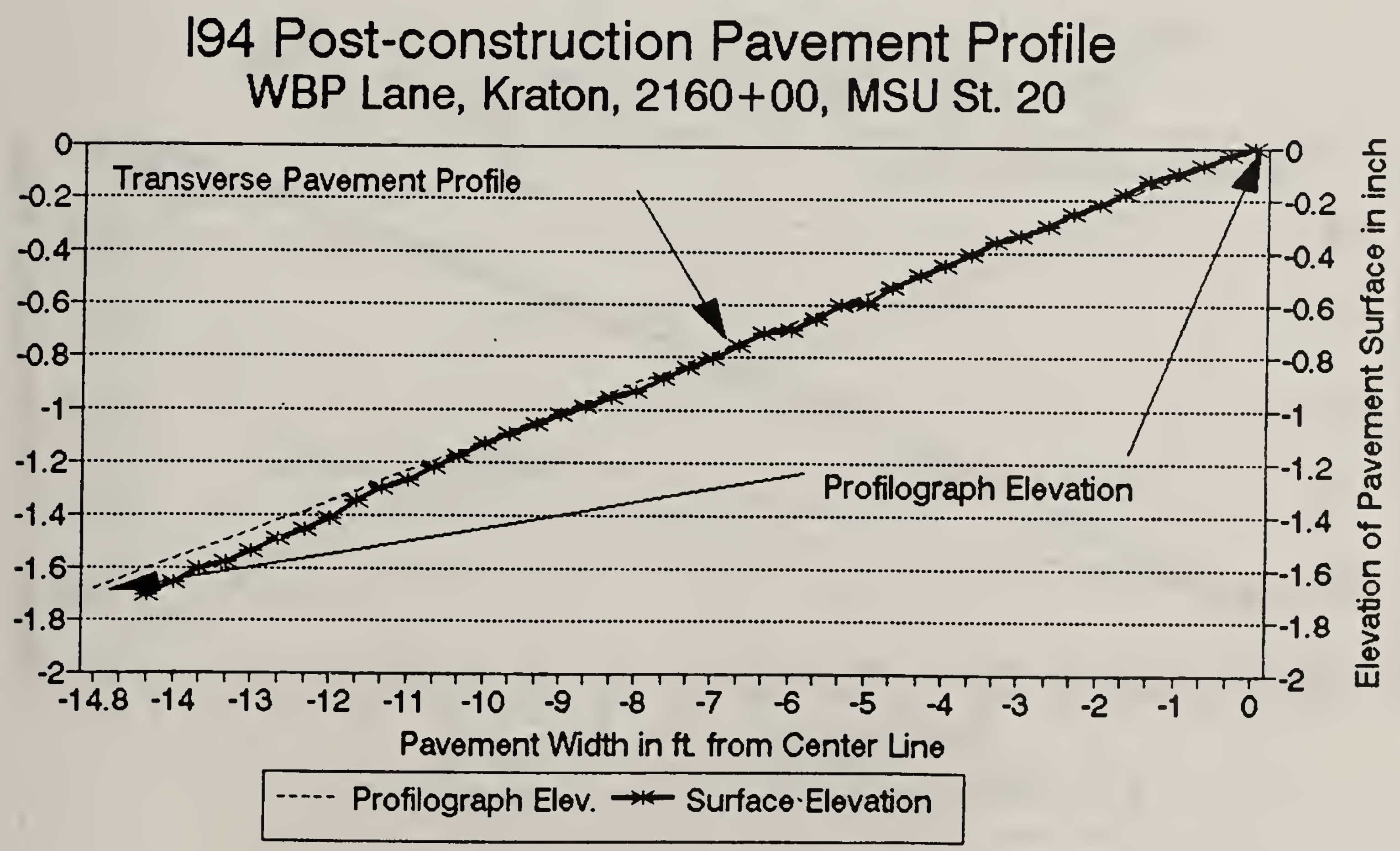
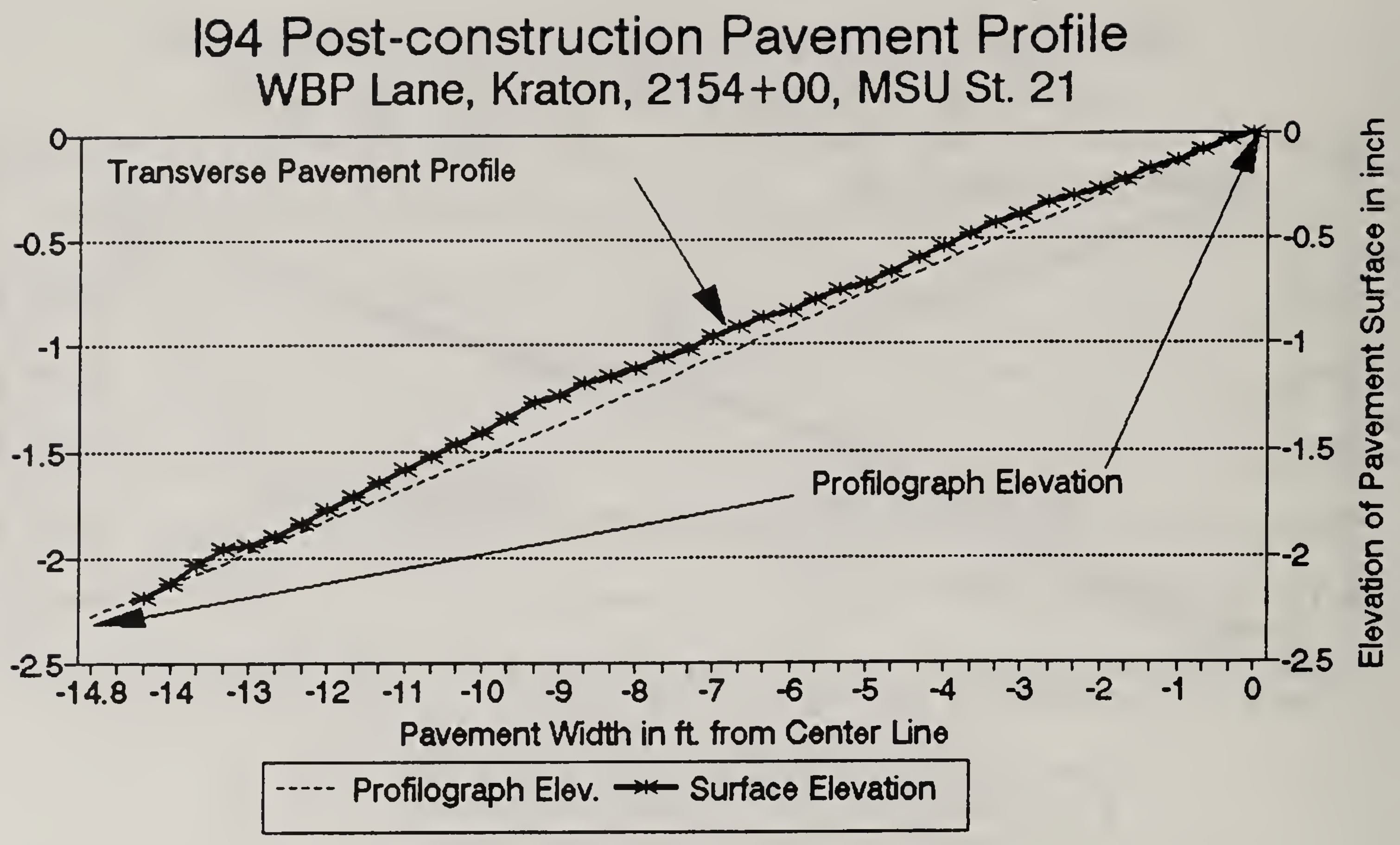


Fig. 10D. Post-construction Profile and Elevation, Center Line of Pavement as Origin


I94 Post-construction Pavement Profile
WBP Lane, Kraton, 2154+00, MSU St. 21

Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

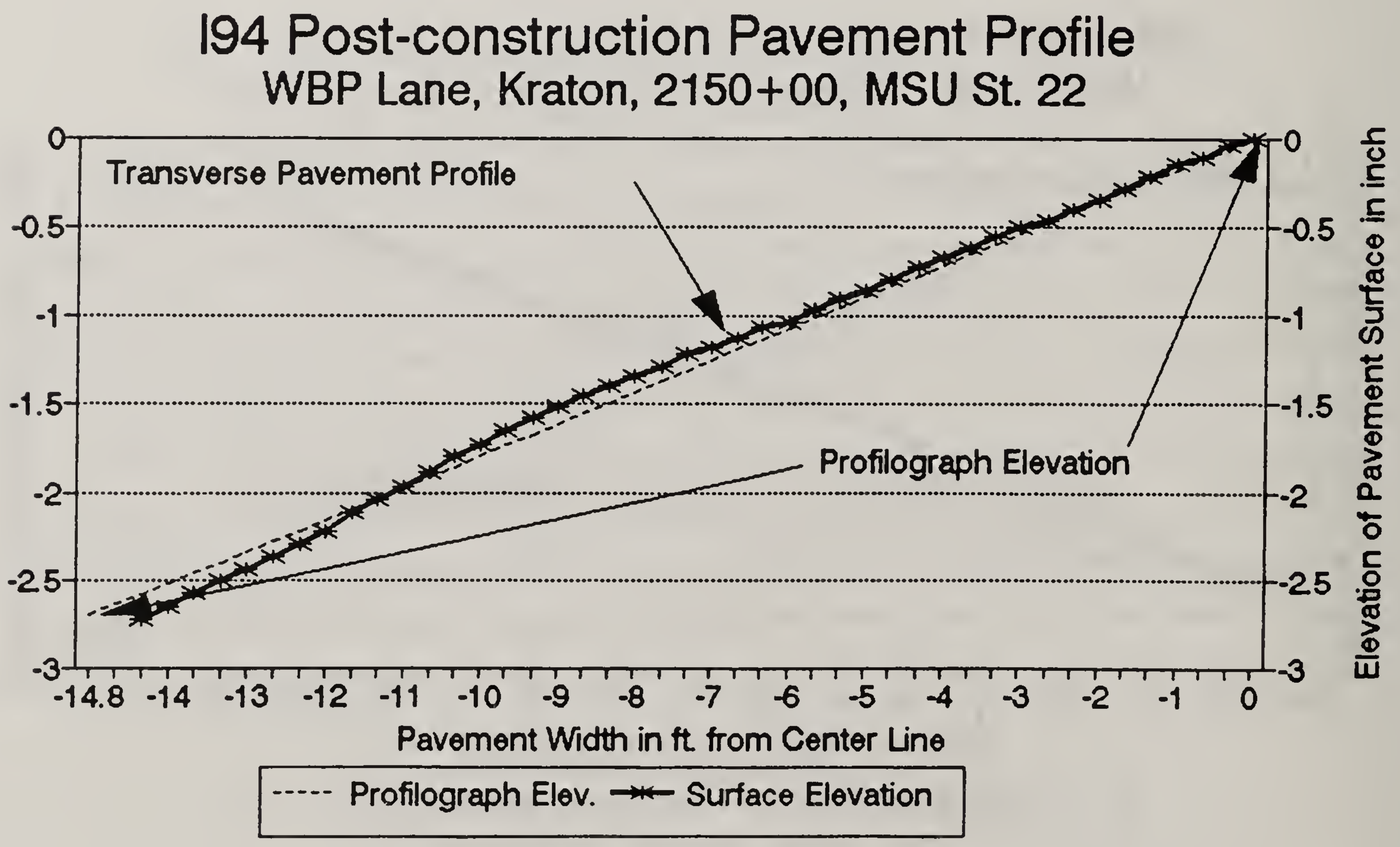
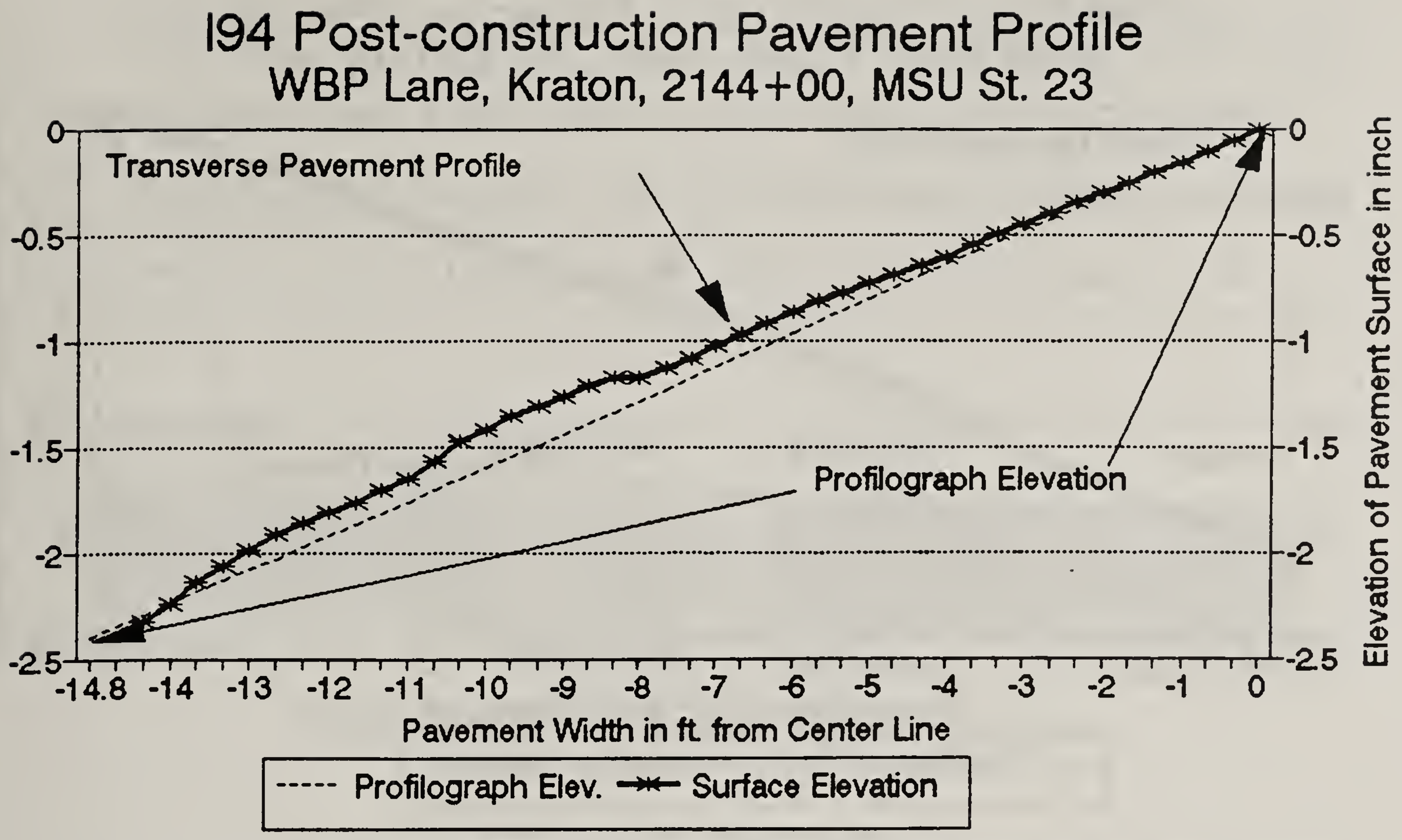

I94 Post-construction Pavement Profile
WBP Lane, Kraton, 2150+00, MSU St. 22

Fig. 11D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

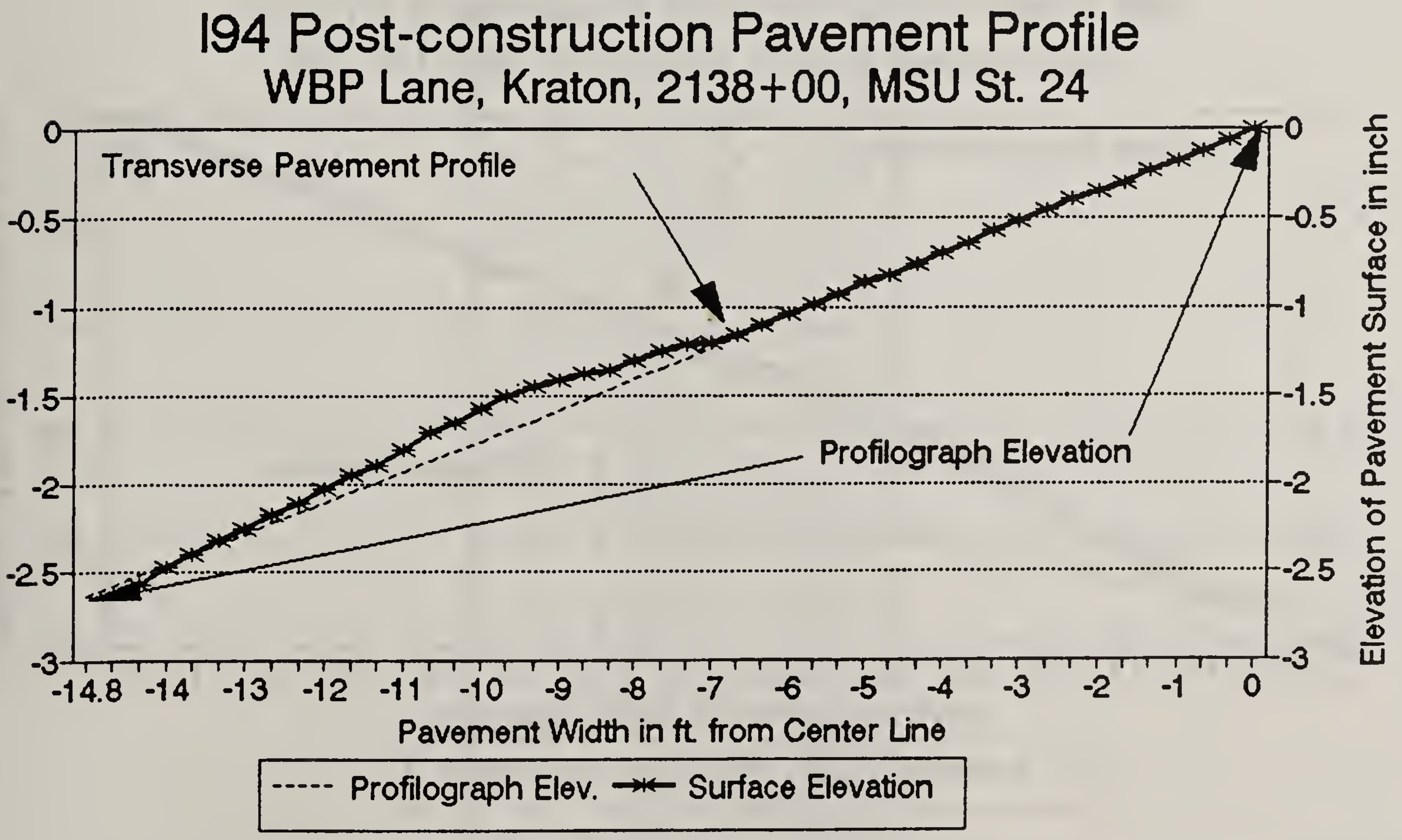
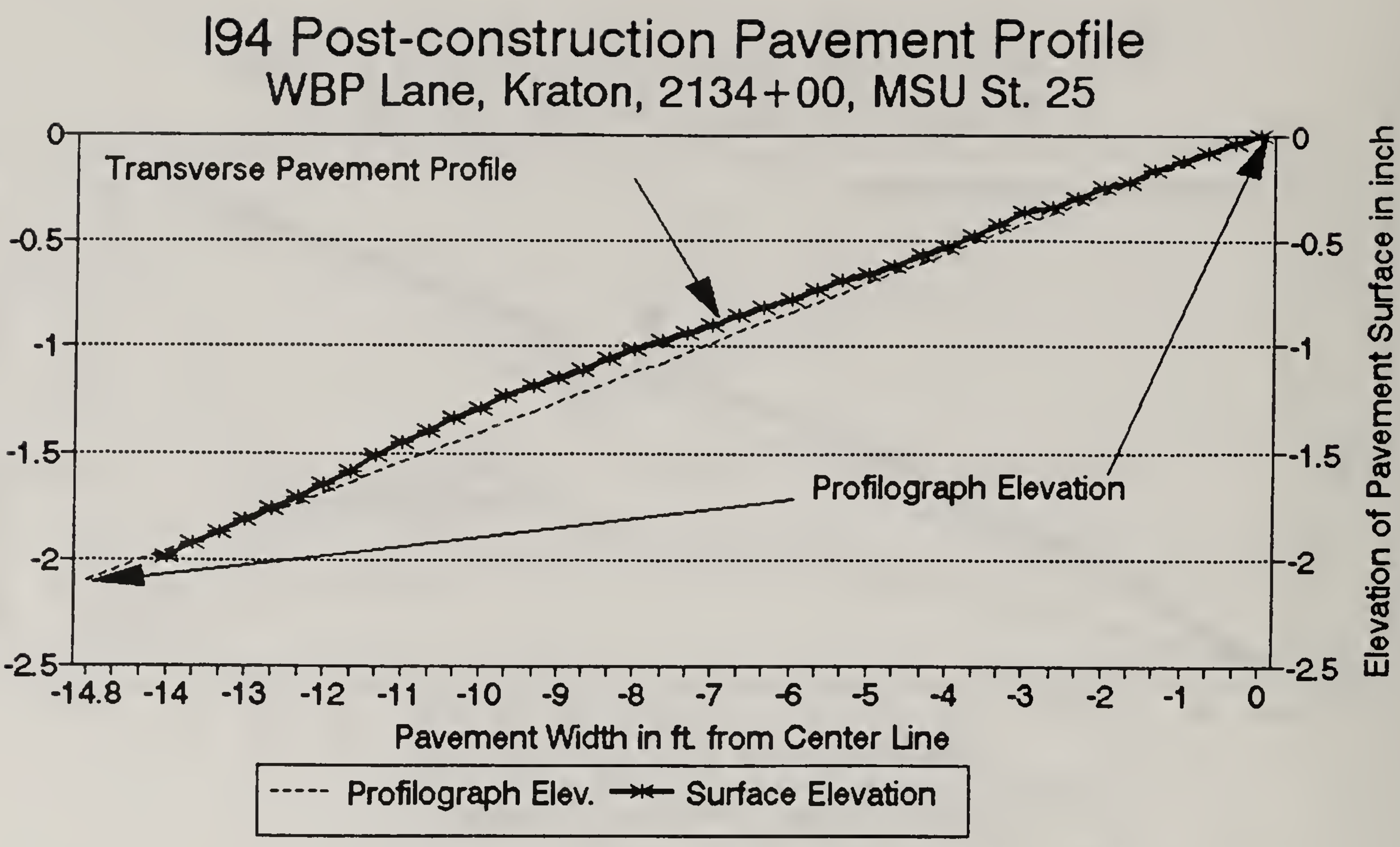


Fig. 12D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: West Bound Driving (WBD) Lane, Kraton Modified Binder Section

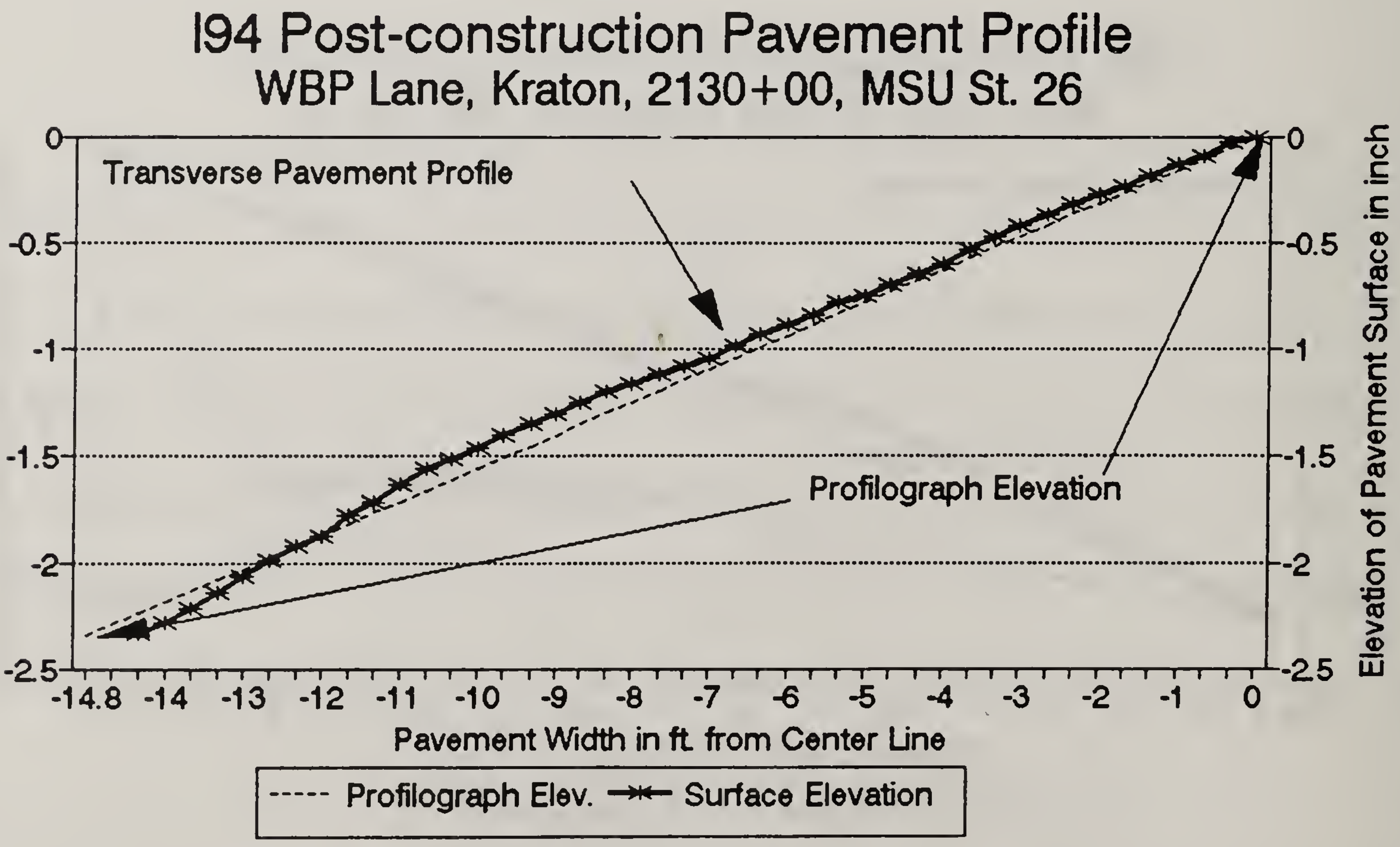
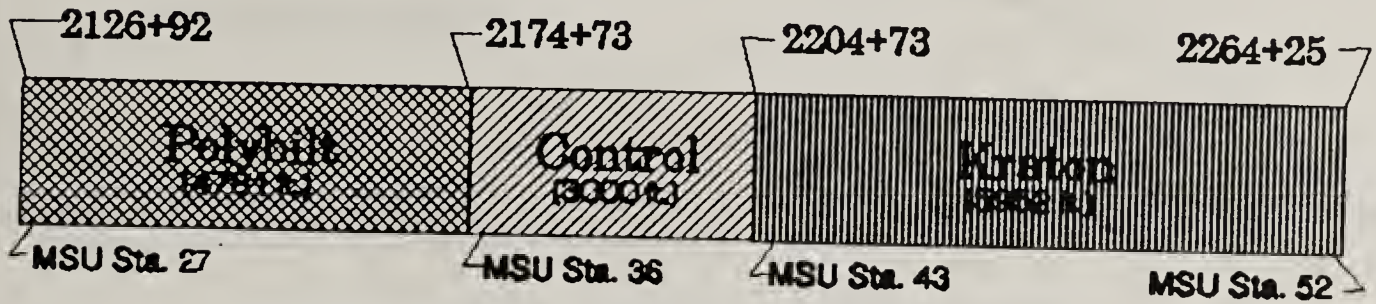


Fig. 13D. Post-construction Profile and Elevation, Center Line of Pavement as Origin

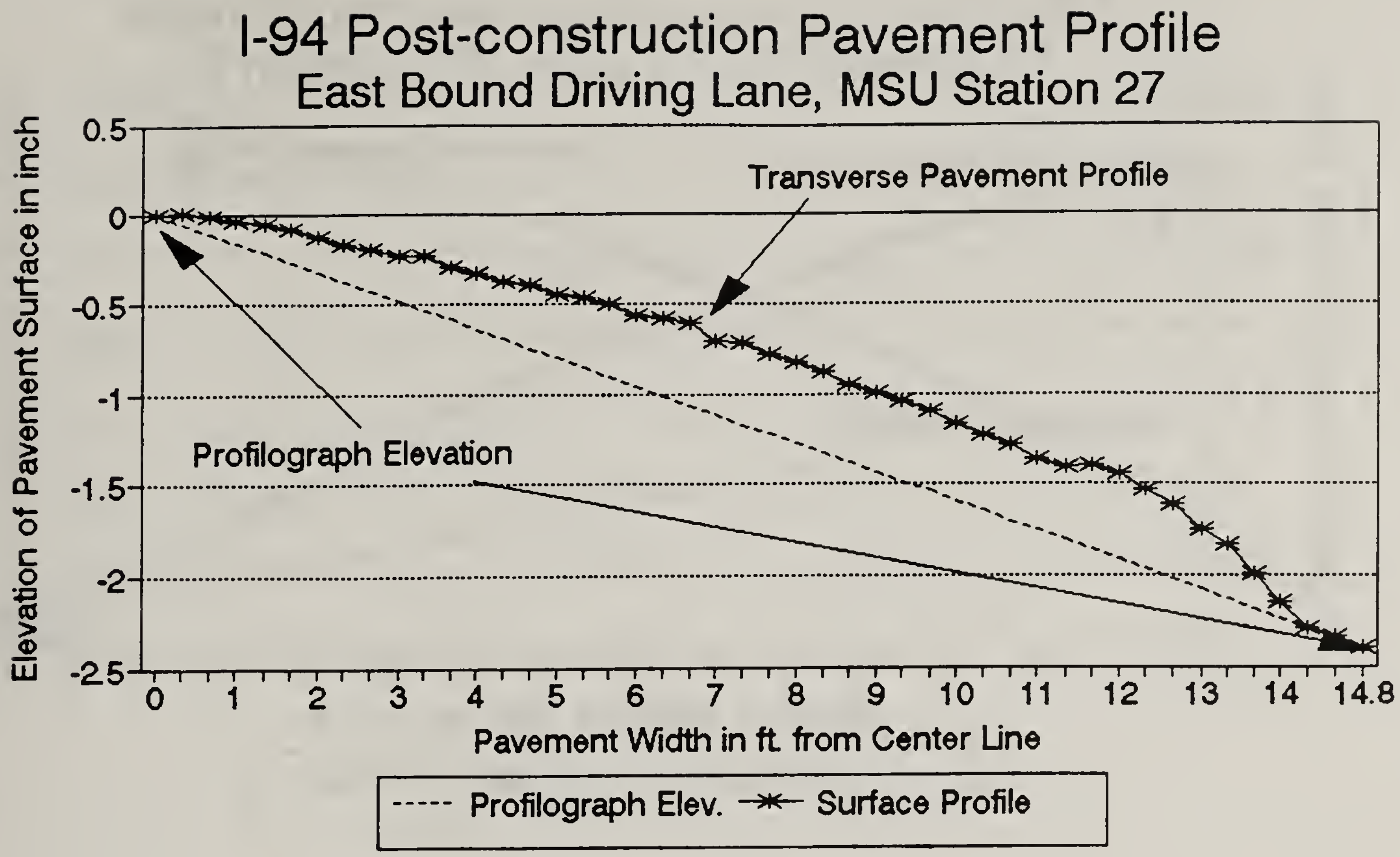
Appendix N

- Figures 14C through 26C - Post-construction Pavement Profile and Elevation of East Bound Driving Lane
- Figures 14D through 26D - Post-construction Pavement Profile and Elevation of East Bound Passing Lane



East Bound Interstate Highway I-94

MSU Station Number	Highway Stations	Section by Binder Used
27	2130+00	Polybilt
28	2134+00	Polybilt
29	2138+00	Polybilt
30	2144+00	Polybilt
31	2150+00	Polybilt
32	2154+00	Polybilt
33	2160+00	Polybilt
34	2164+00	Polybilt
35	2170+00	Polybilt
36	2176+00	Exxon
37	2180+00	Exxon
38	2184+00	Exxon
39	2188+00	Exxon
40	2192+00	Exxon
41	2196+00	Exxon
42	2200+00	Exxon
43	2208+00	Kraton
44	2214+00	Kraton
45	2220+00	Kraton
46	2226+00	Kraton
47	2232+00	Kraton
48	2238+00	Kraton
49	2244+00	Kraton
50	2250+00	Kraton
51	2254+00	Kraton
52	2260+00	Kraton



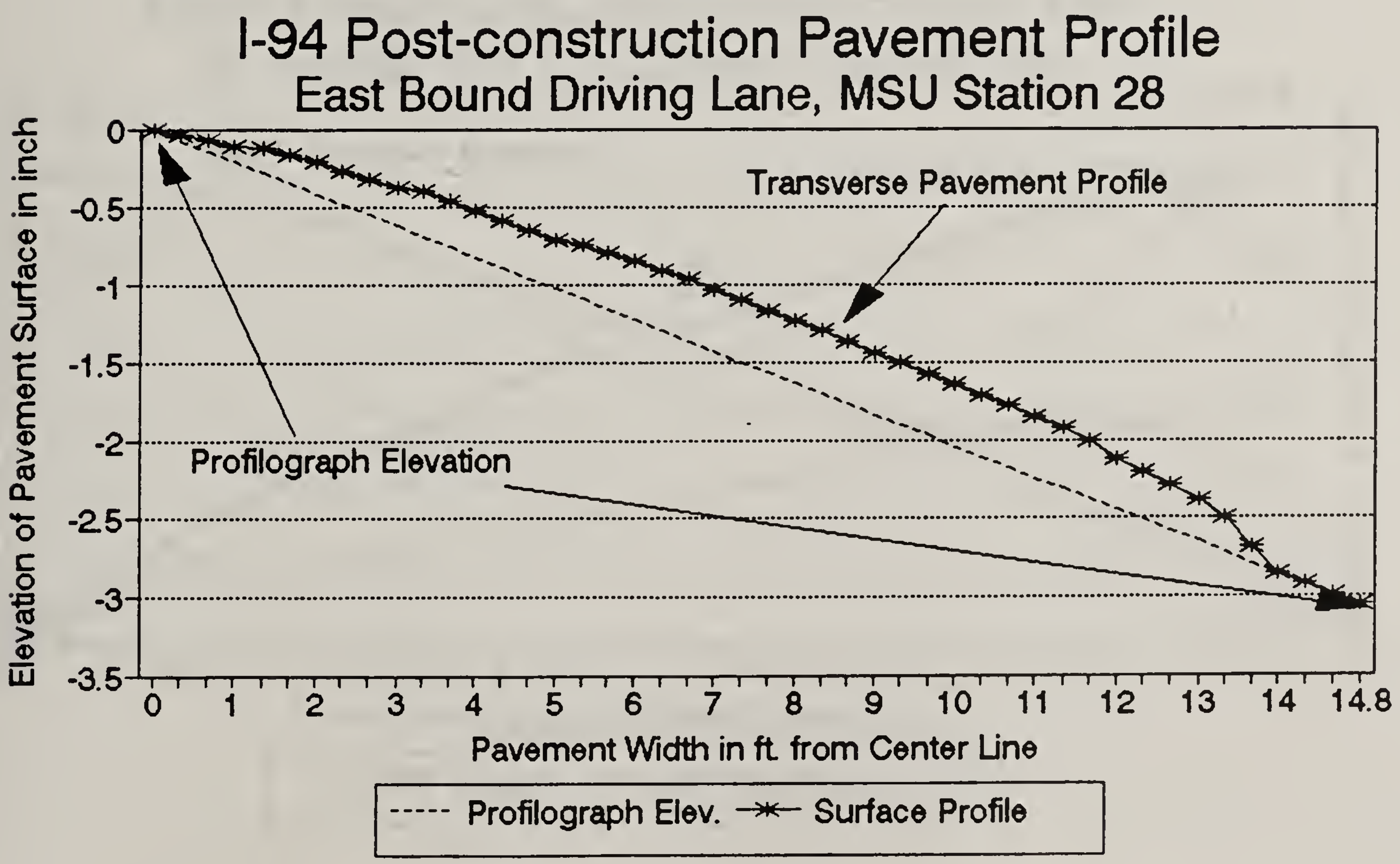
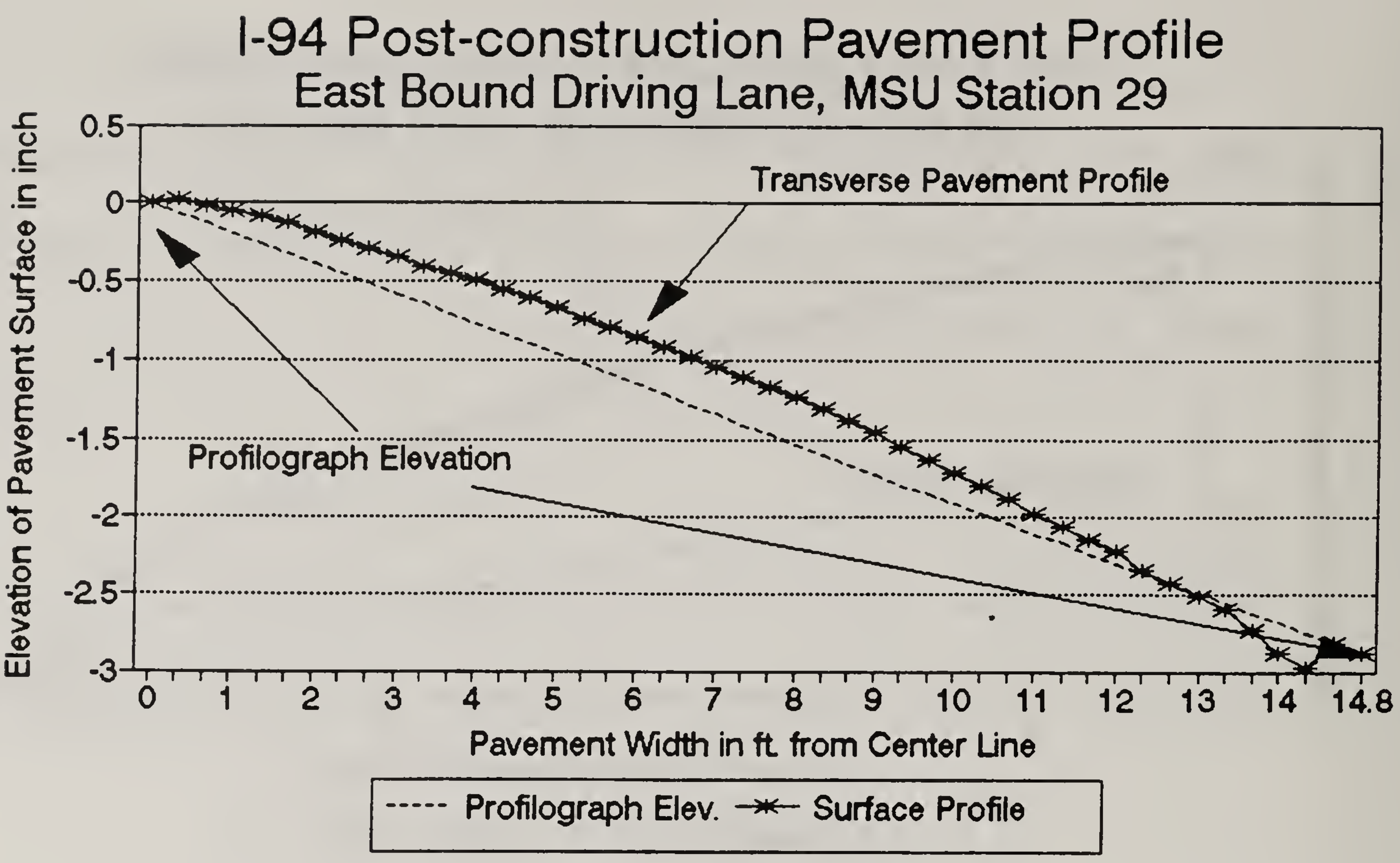


Fig. 14C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



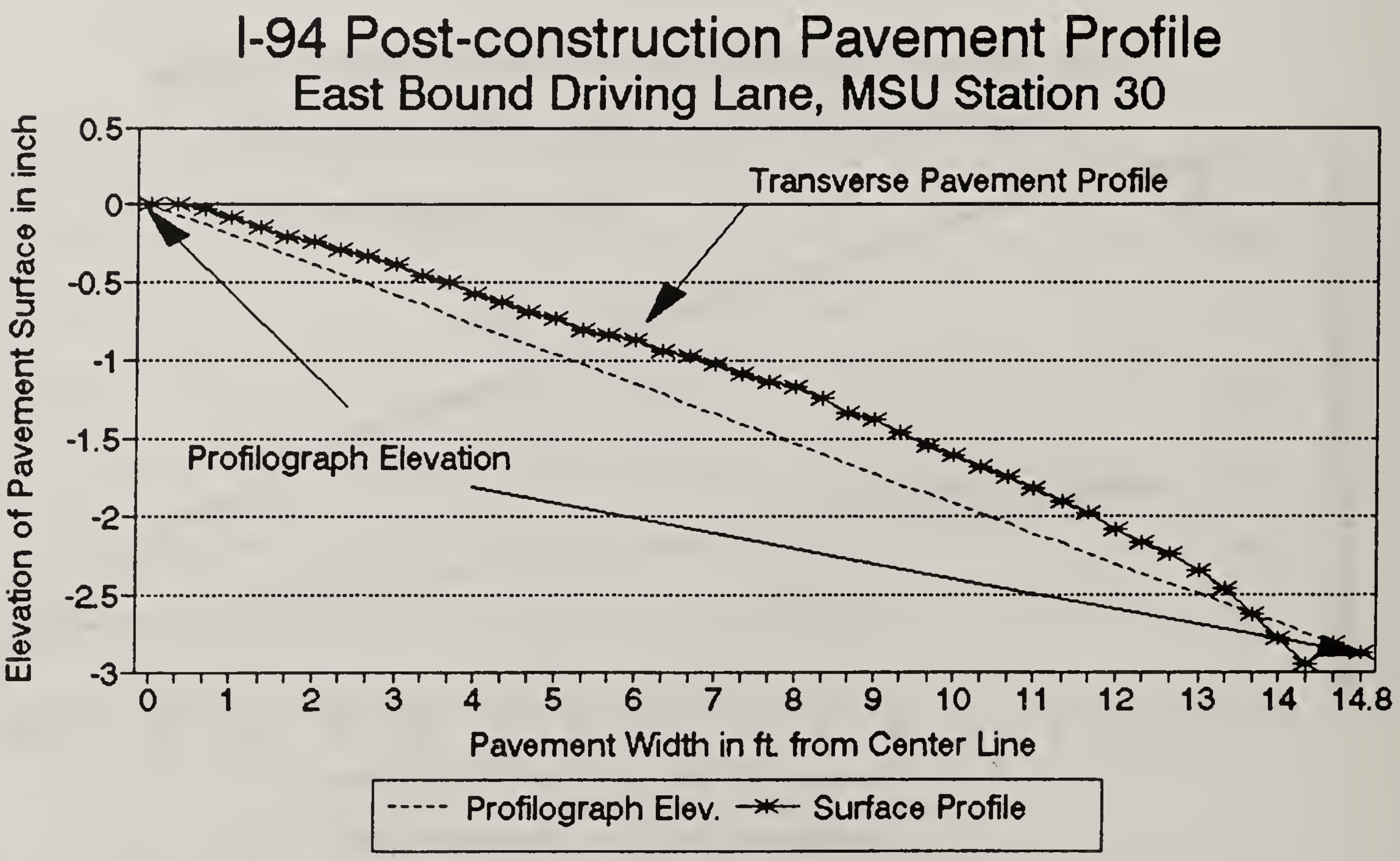
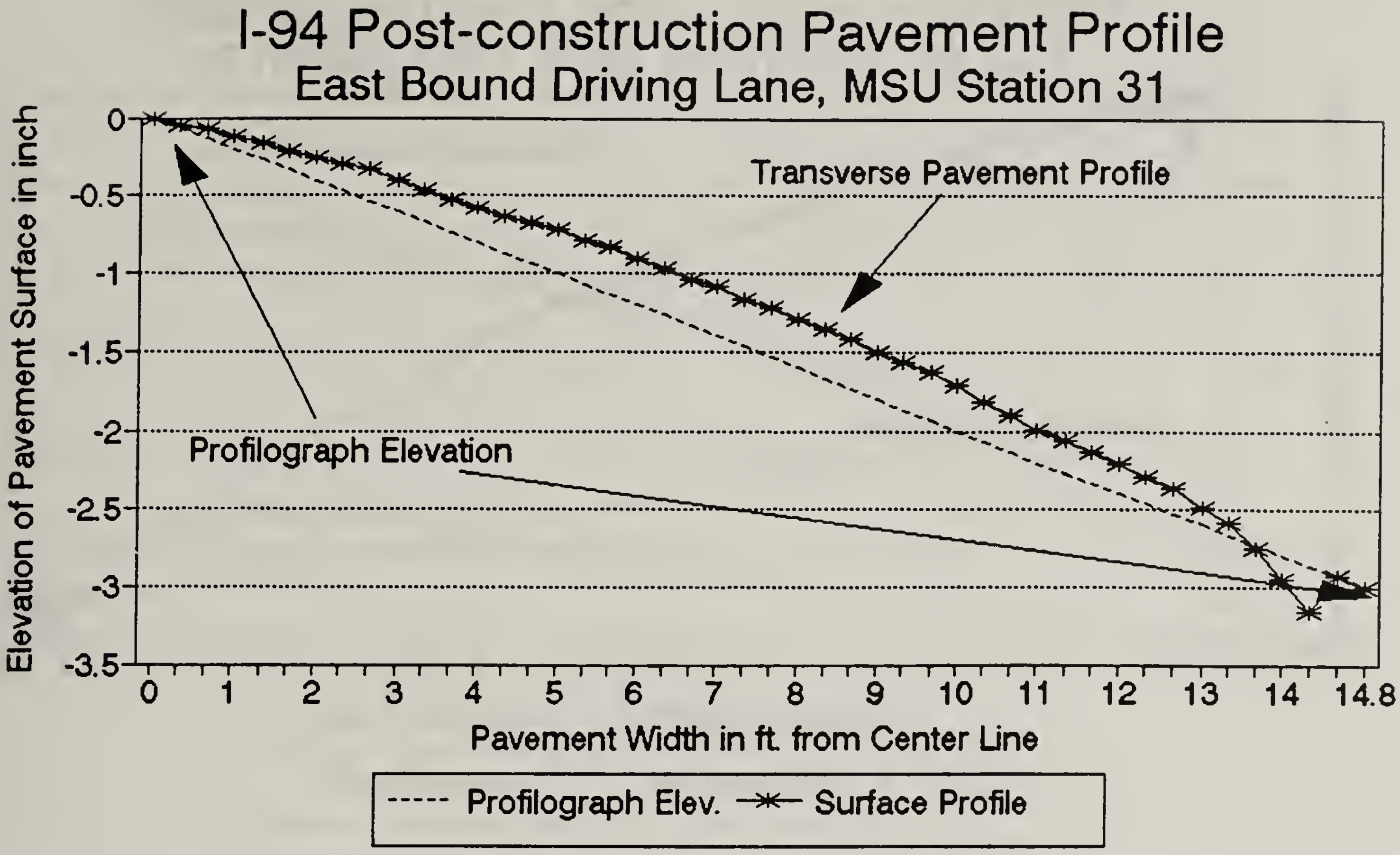


Fig. 15C. Post-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Post-construction Pavement Profile
East Bound Driving Lane, MSU Station 31

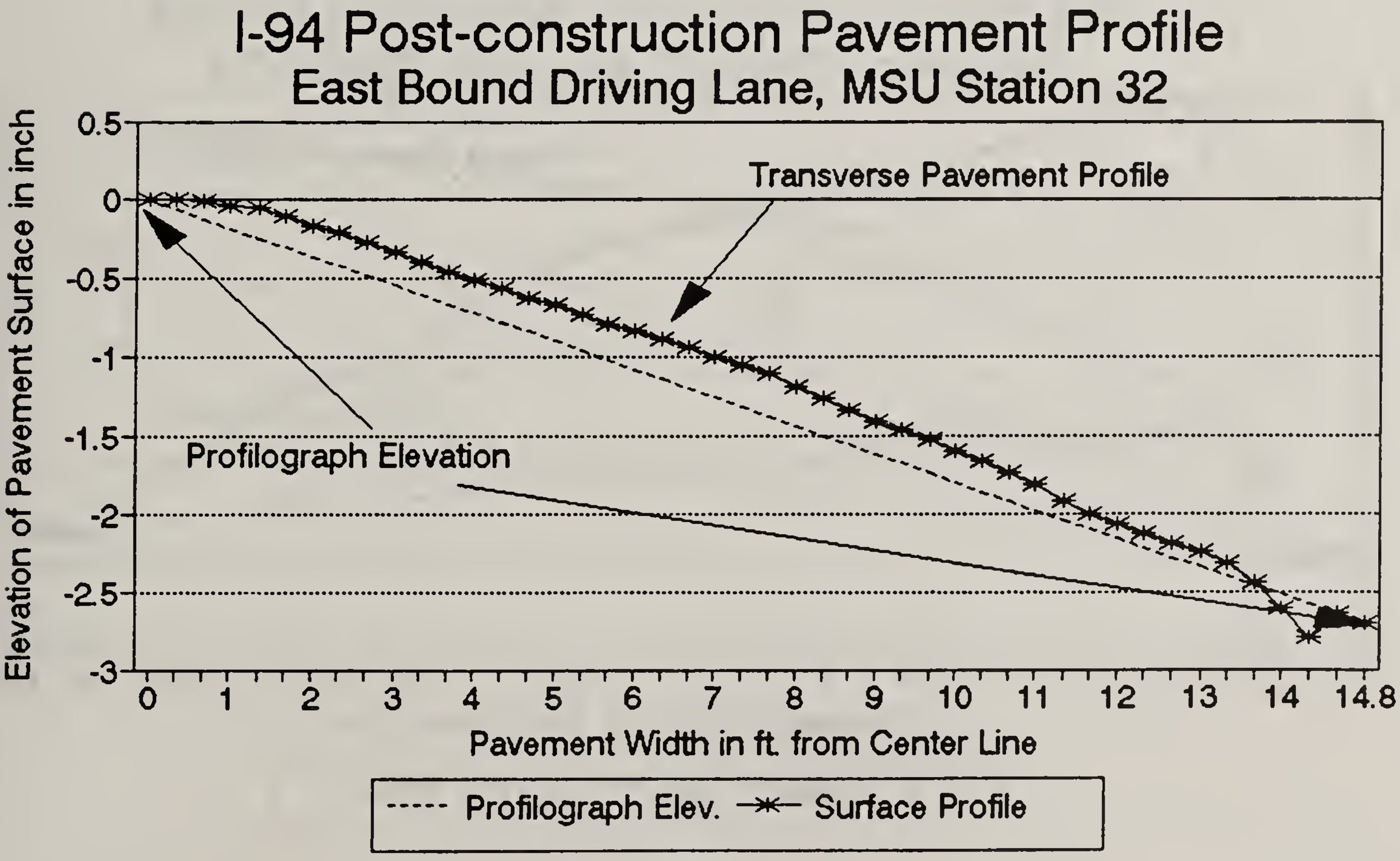
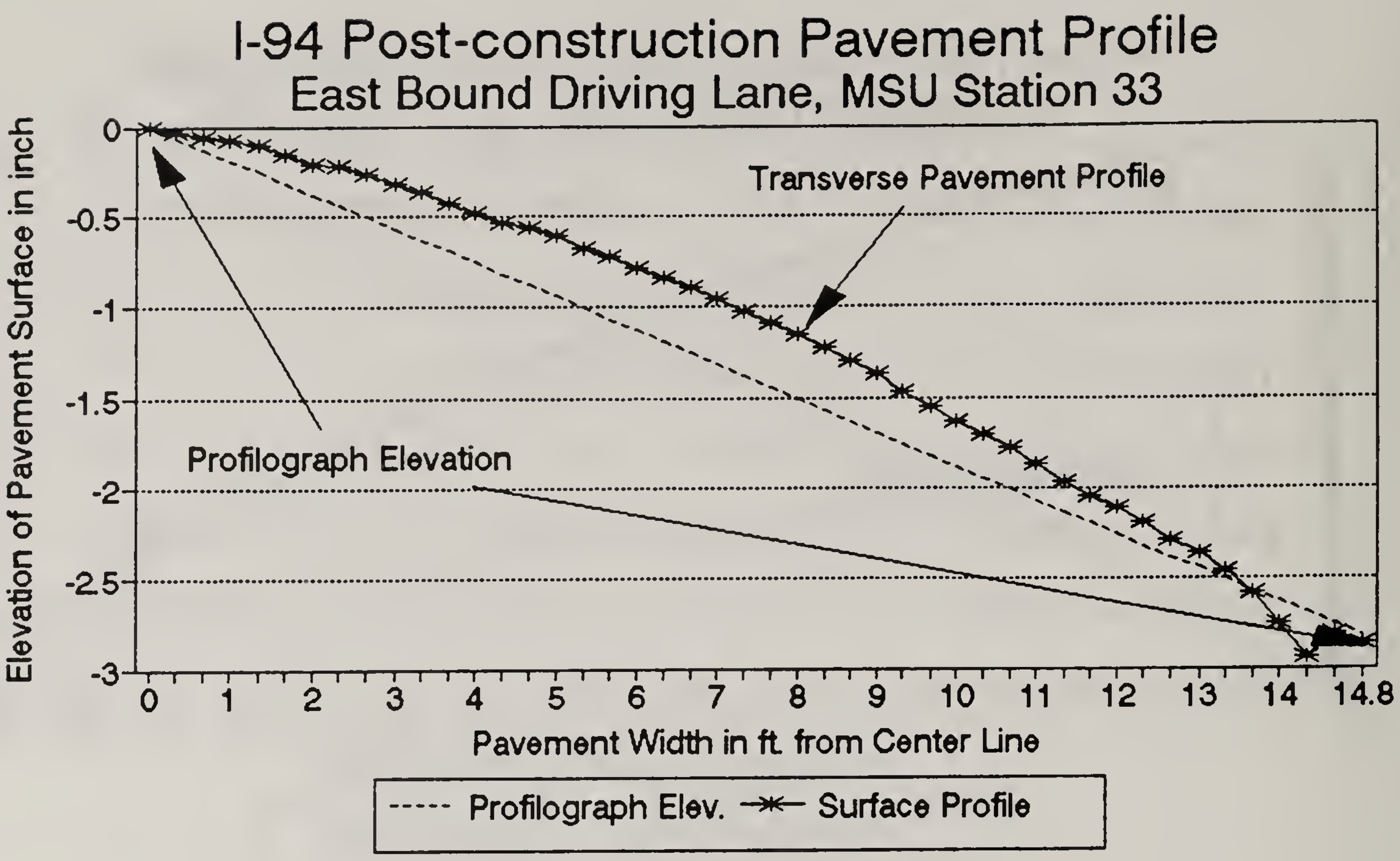

I-94 Post-construction Pavement Profile
East Bound Driving Lane, MSU Station 32

Fig. 16C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



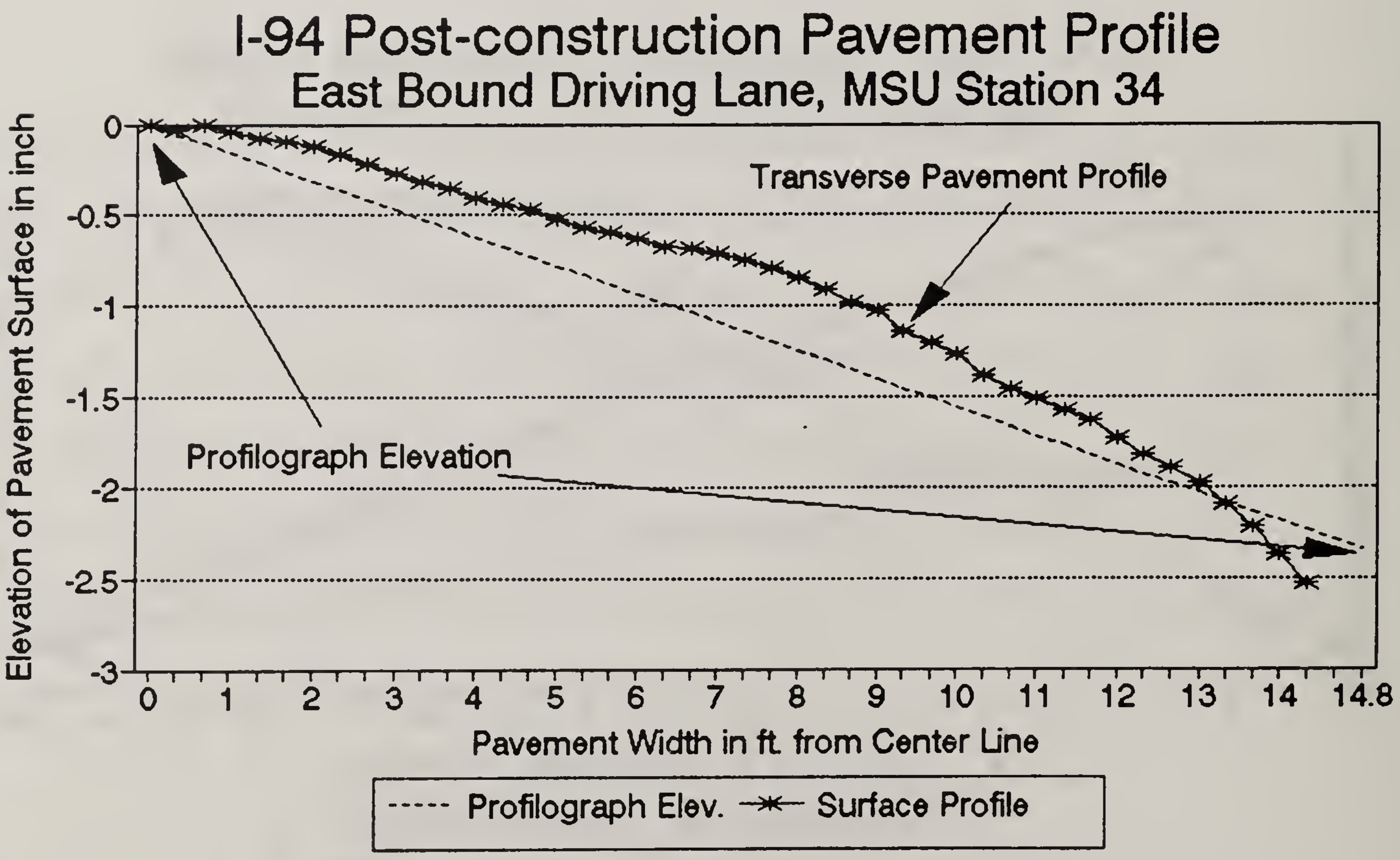
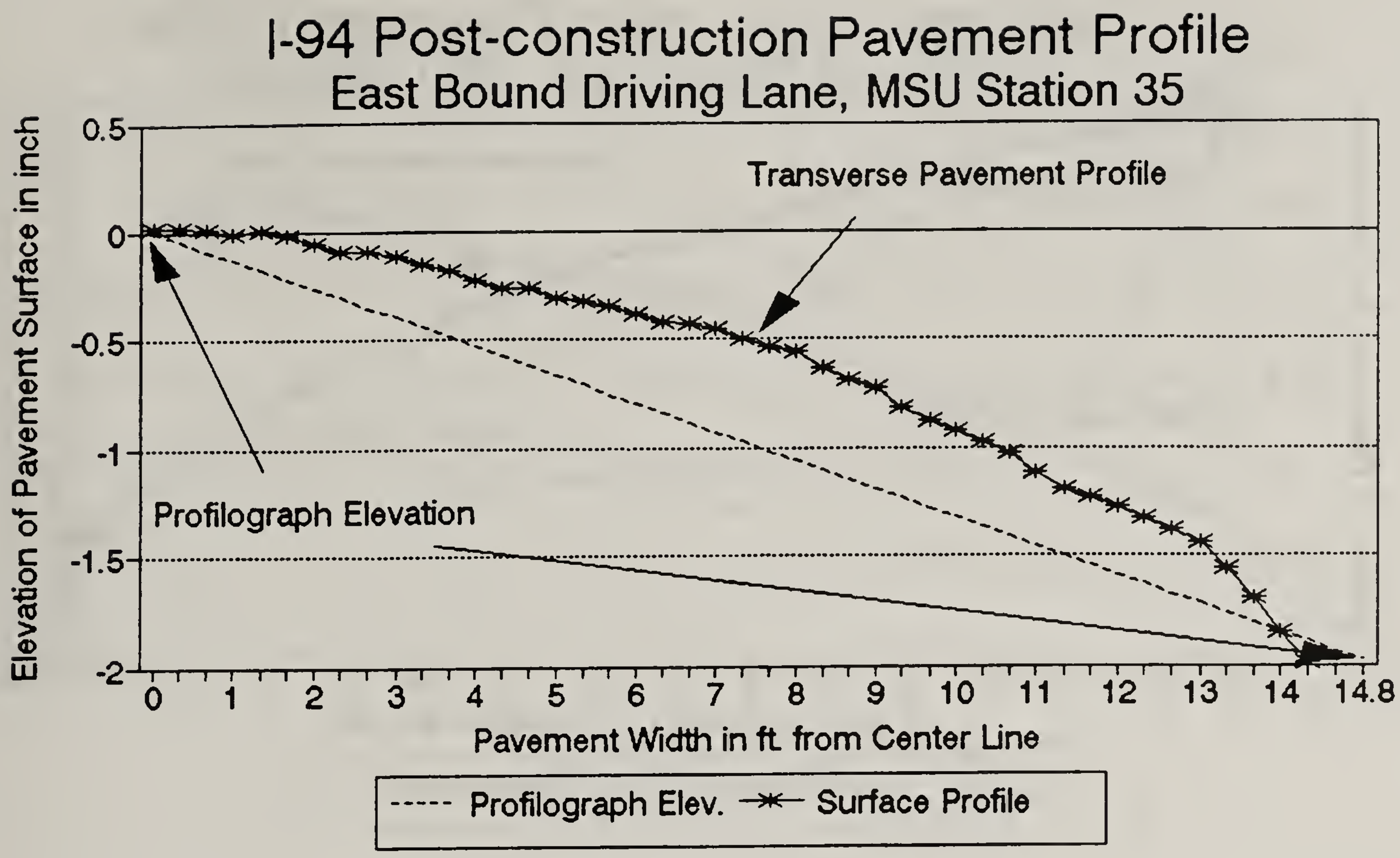


Fig. 17C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



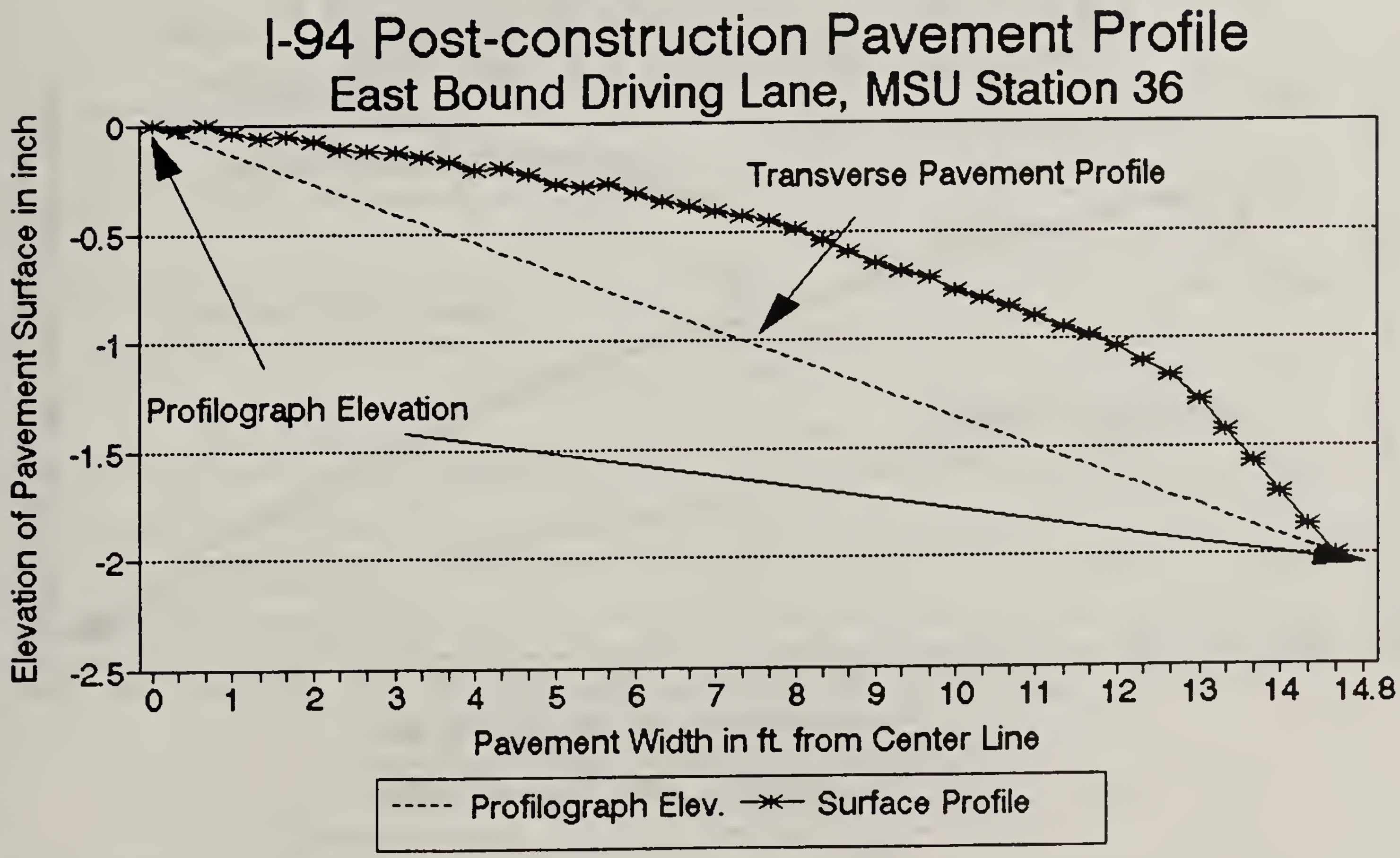
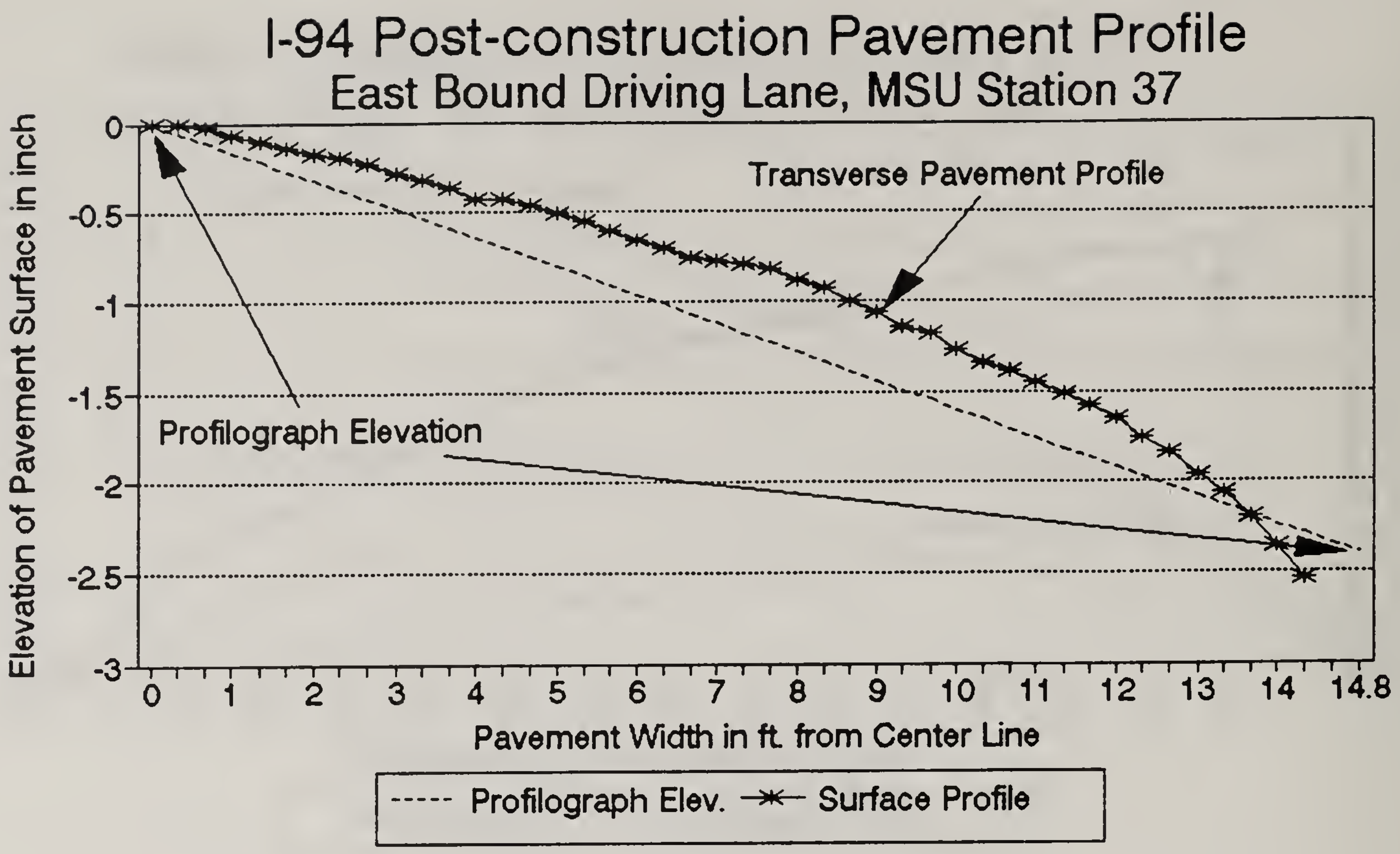


Fig. 18C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



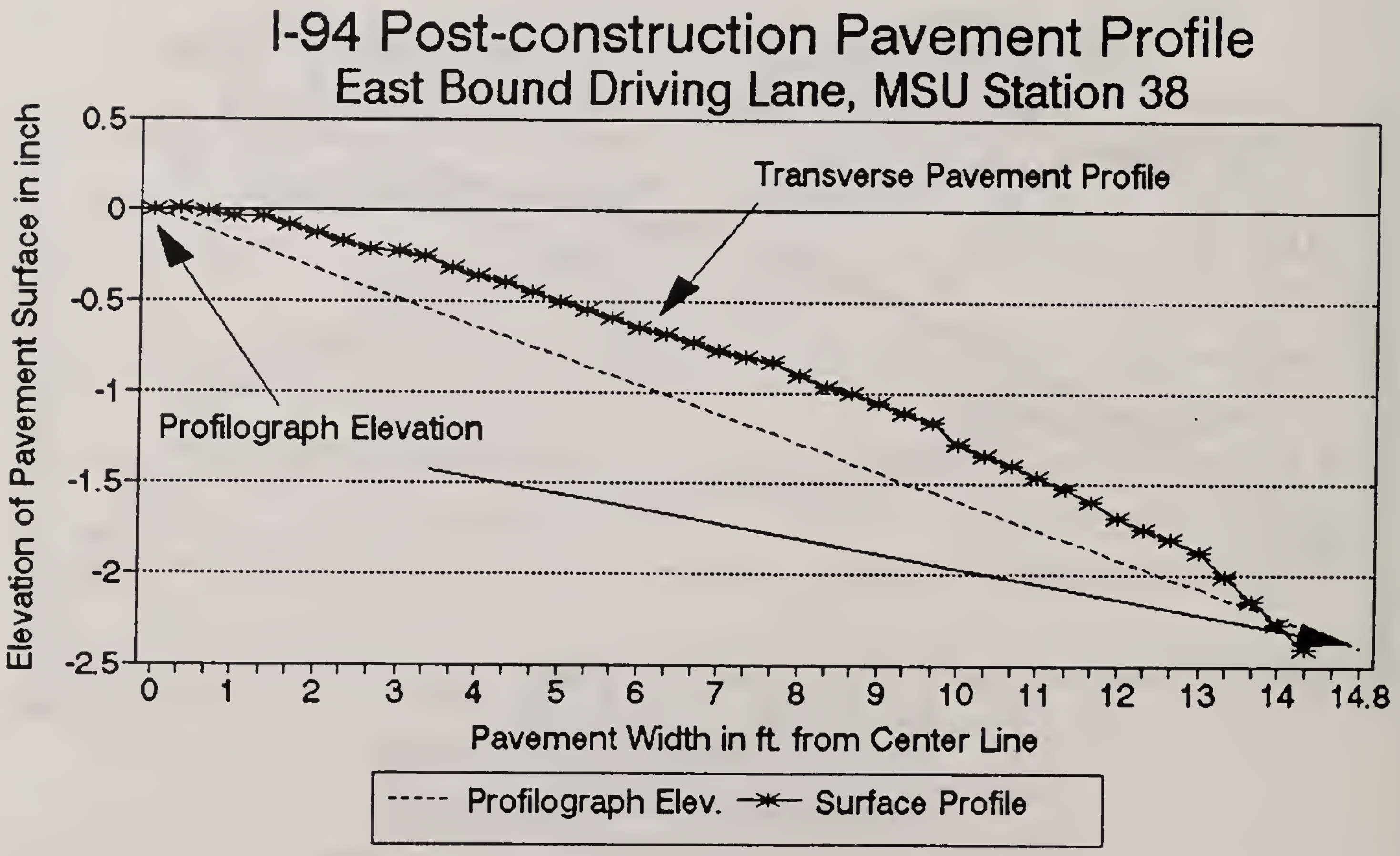
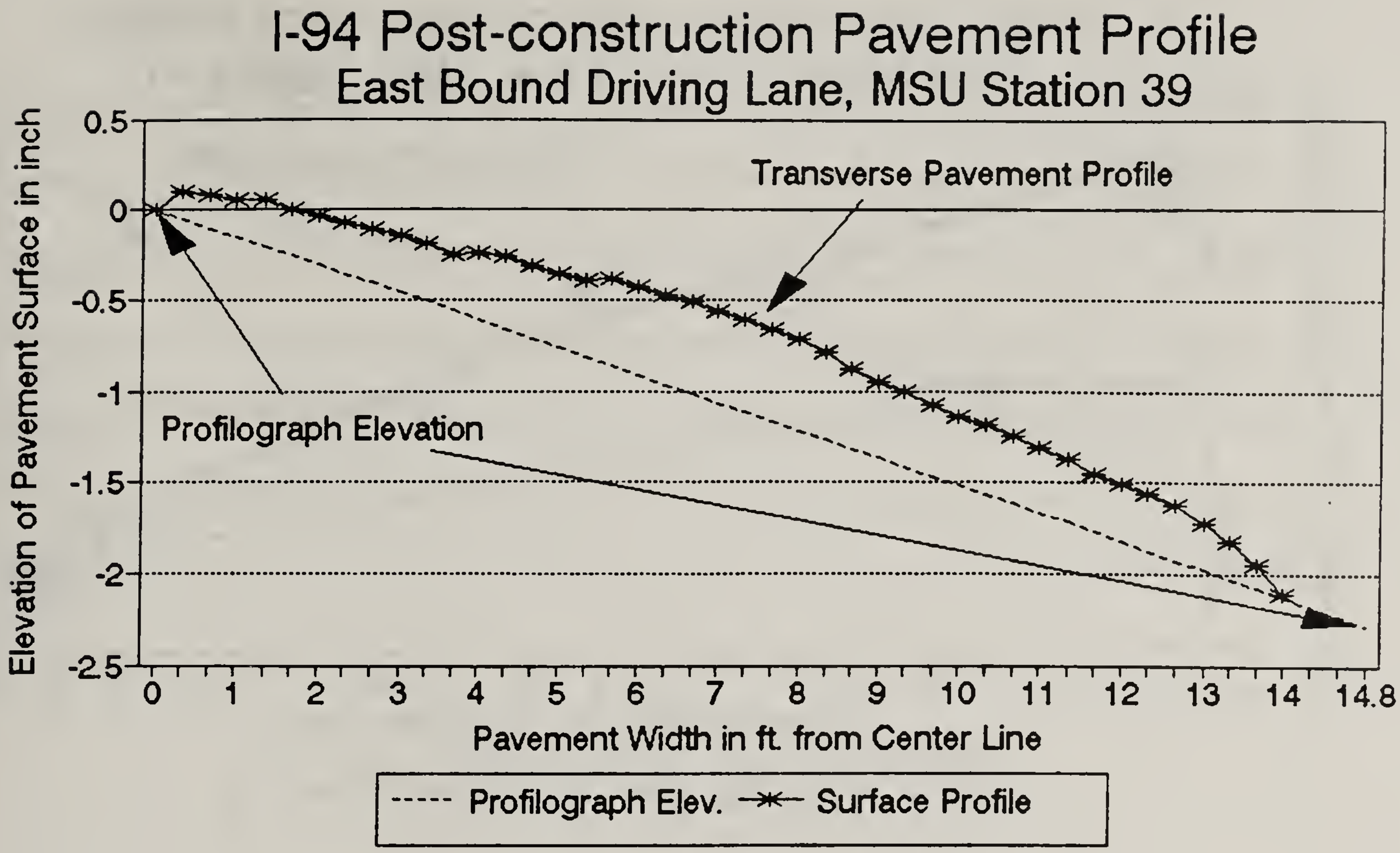


Fig. 19C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



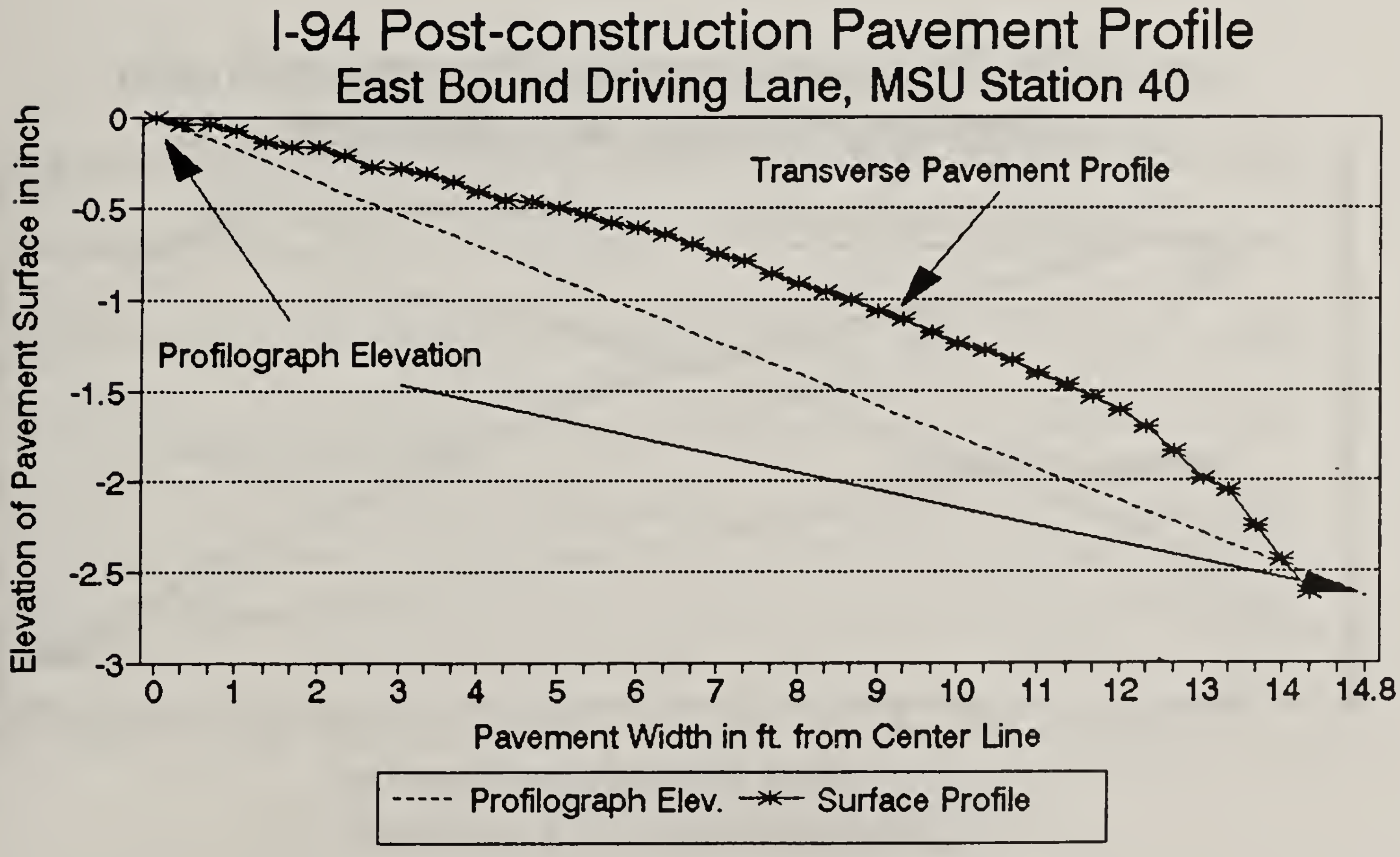
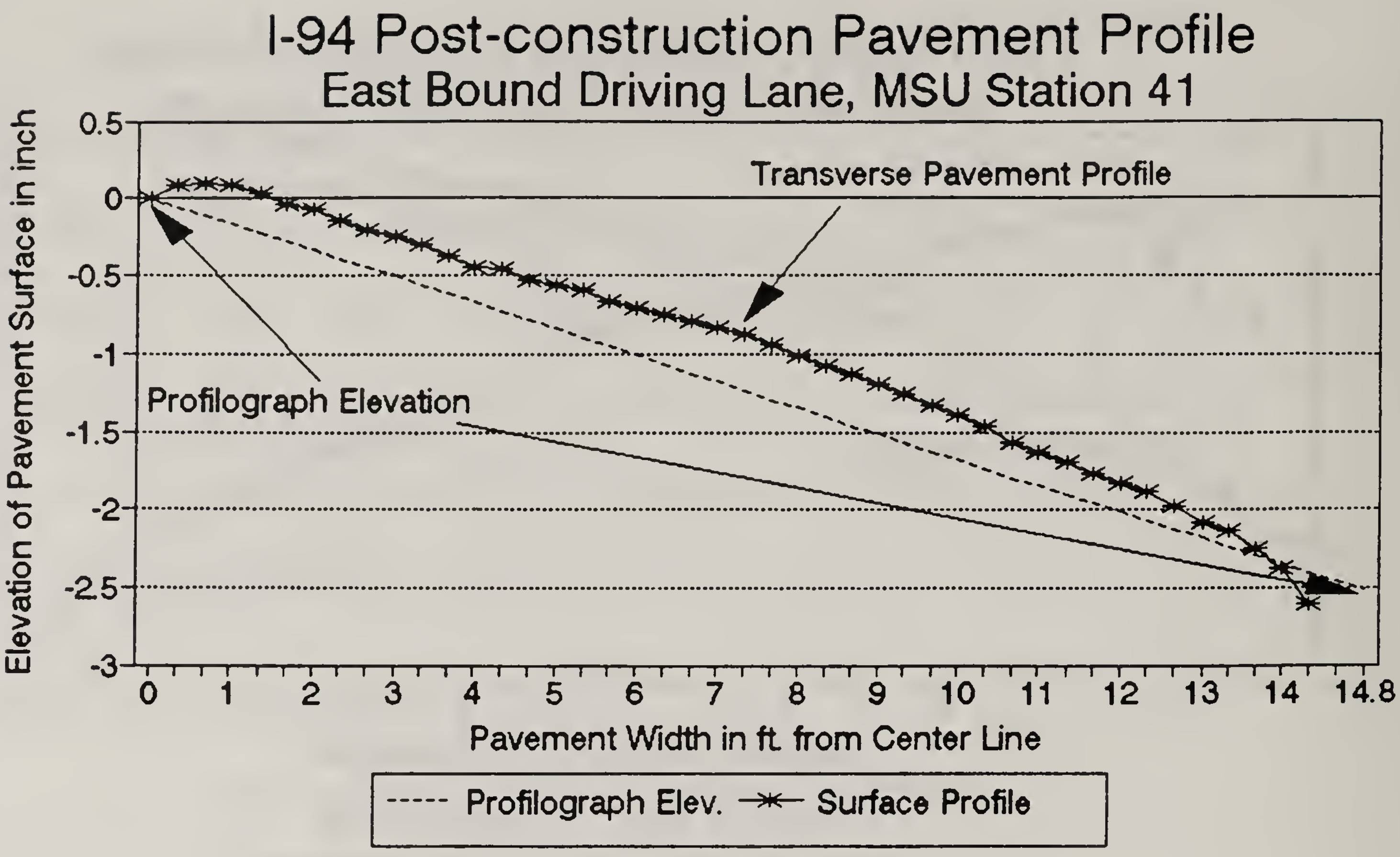


Fig. 20C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



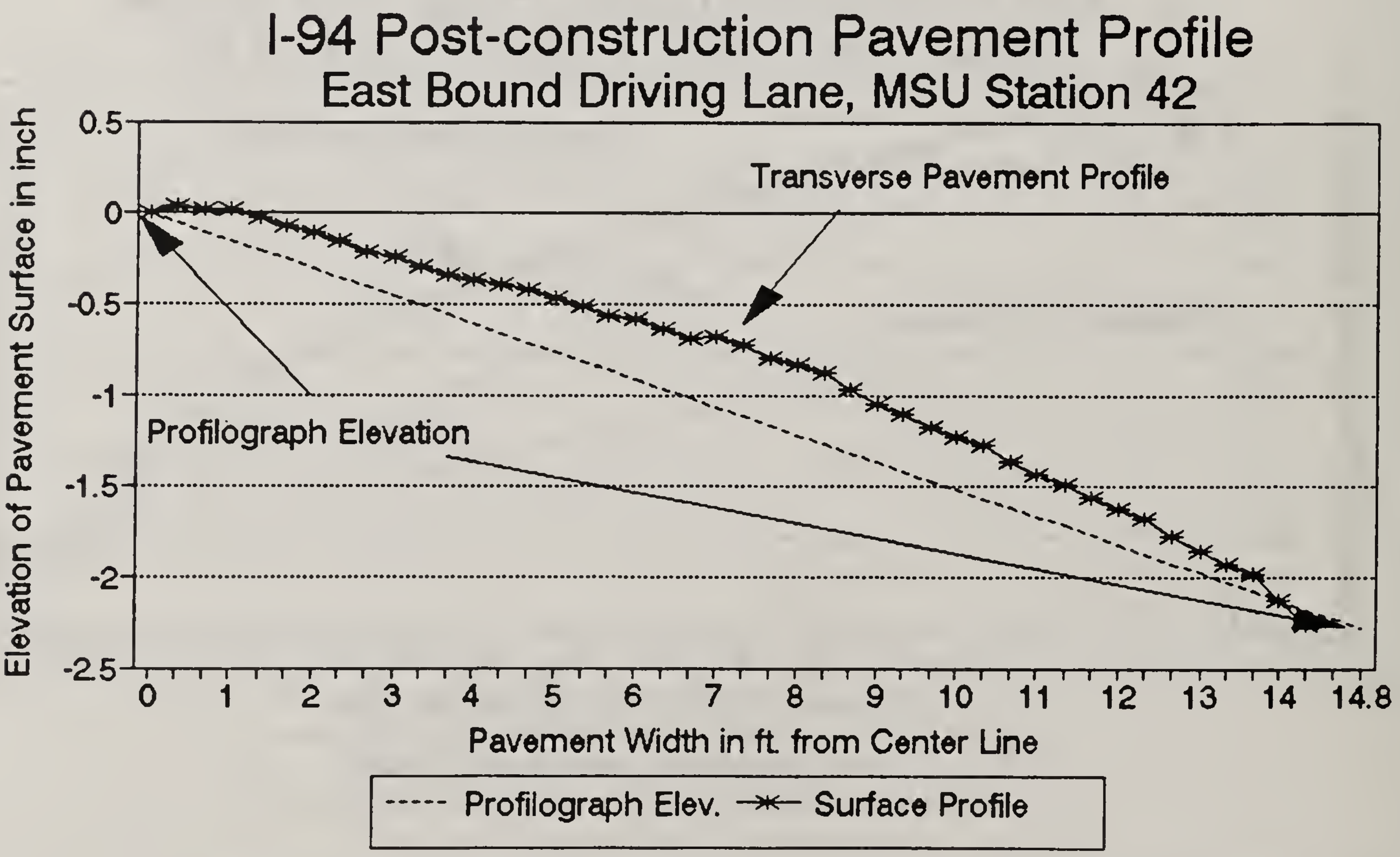
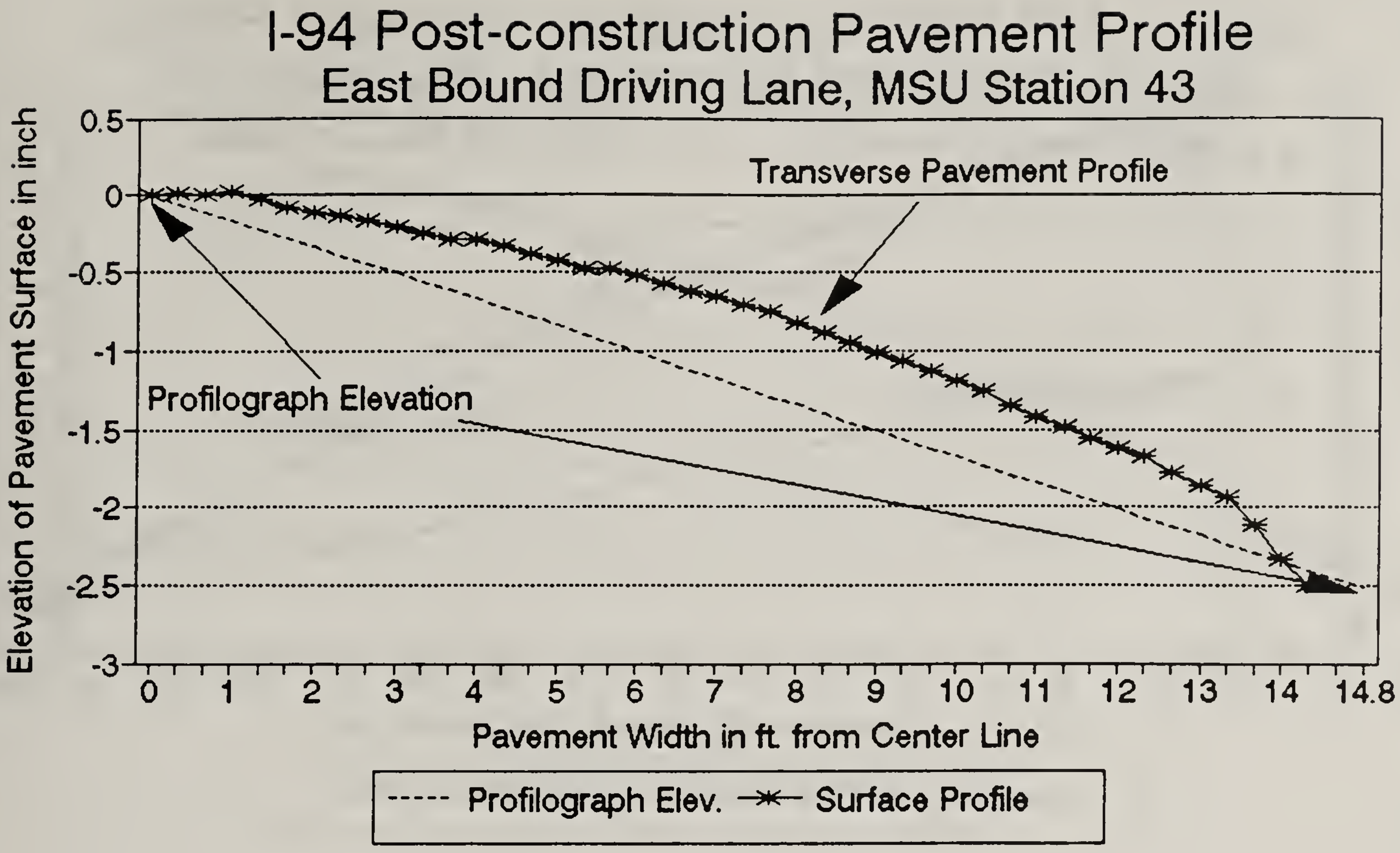


Fig. 21. Post-costruction Profile and Elevation, Center Line of Pavement as Origin



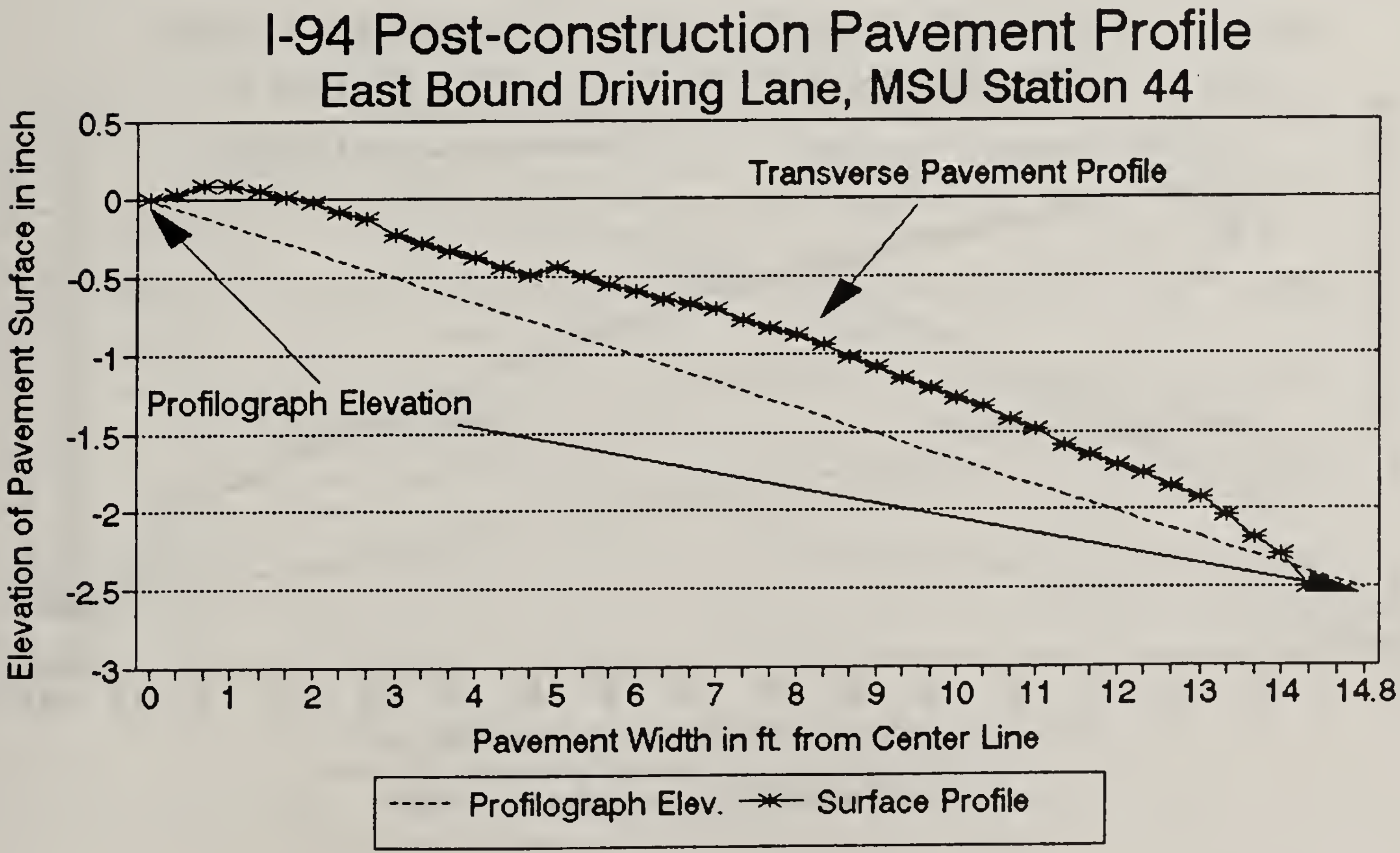
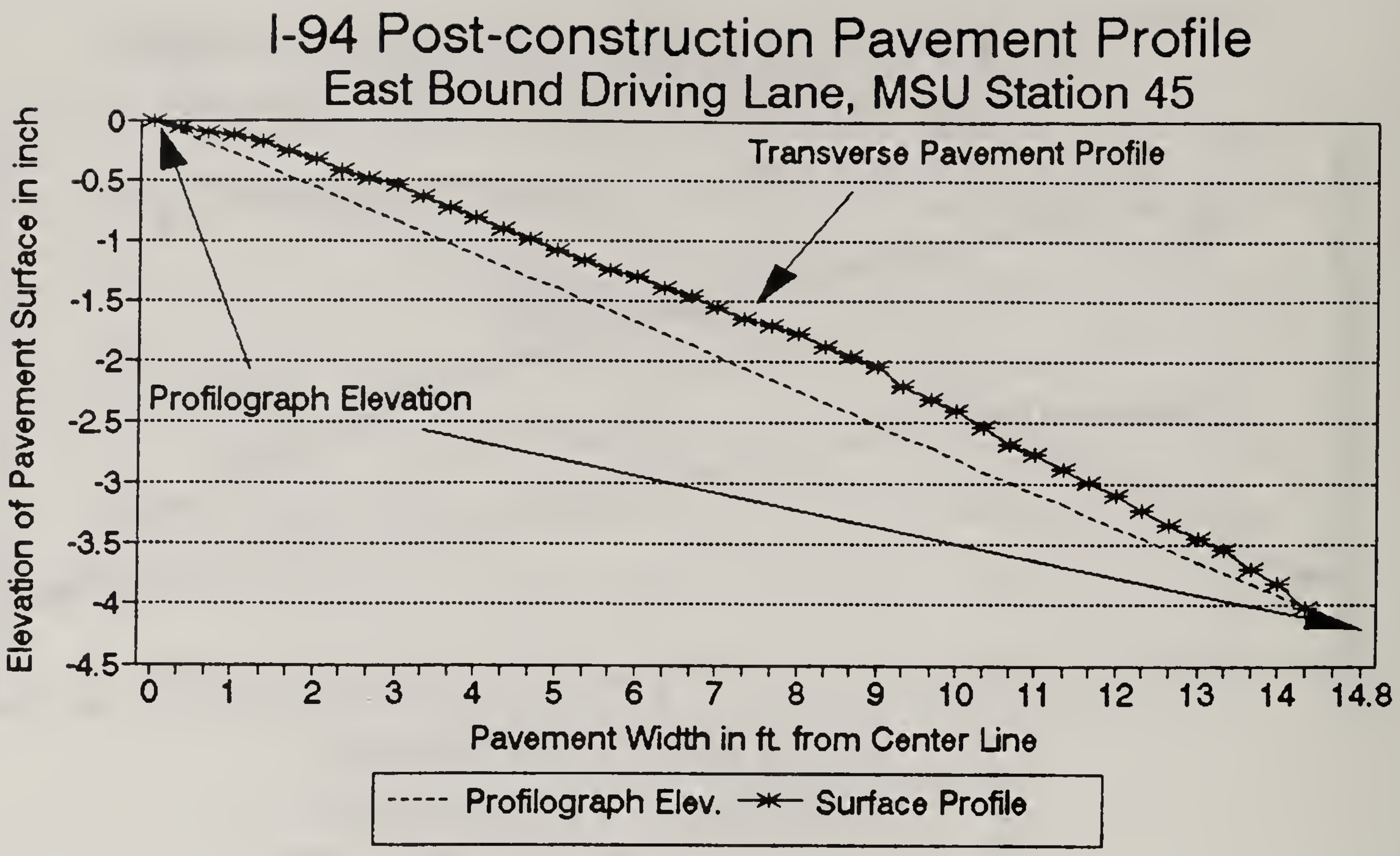


Fig. 22C. Post-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Post-construction Pavement Profile
East Bound Driving Lane, MSU Station 45

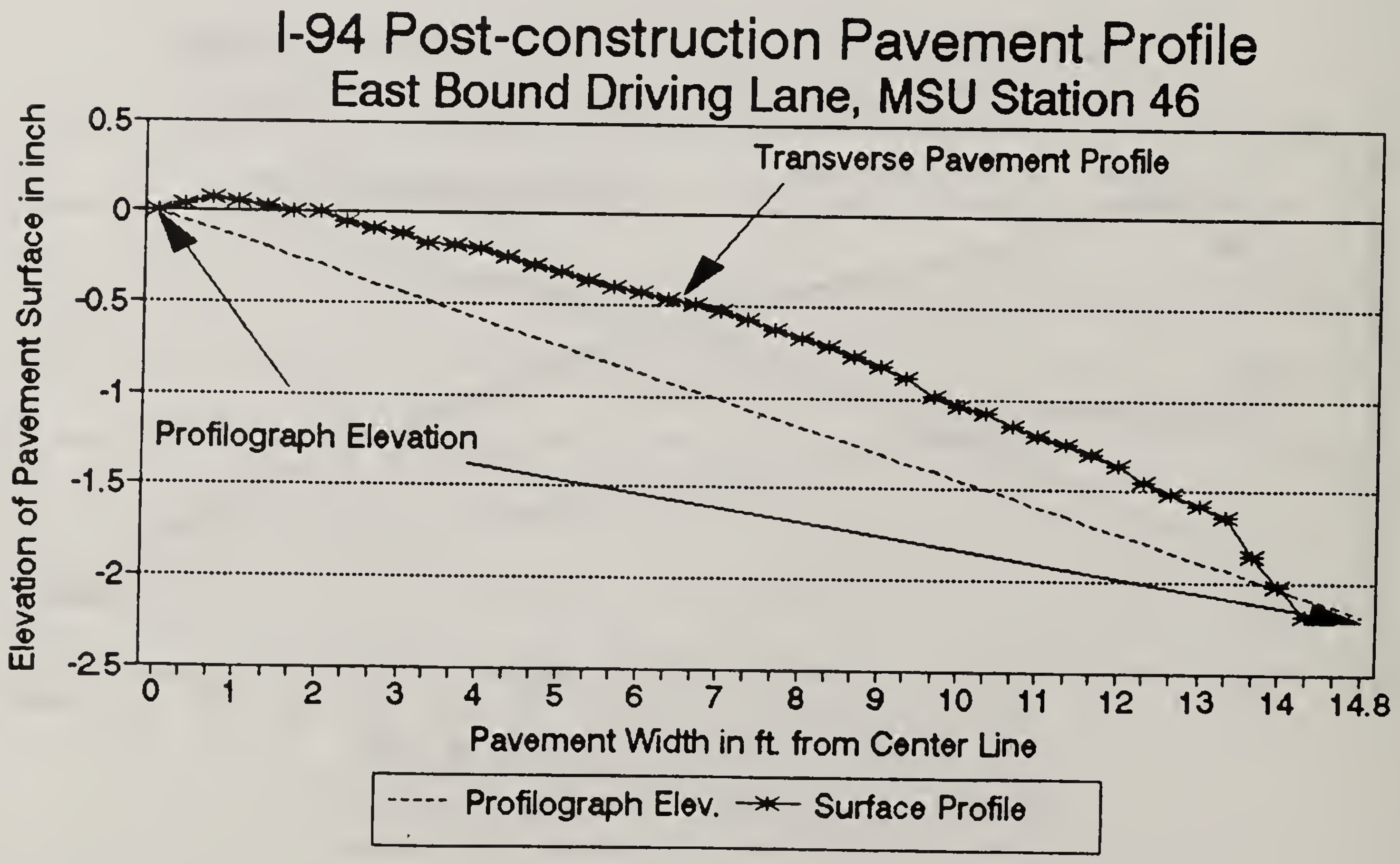

I-94 Post-construction Pavement Profile
East Bound Driving Lane, MSU Station 46

Fig. 23C. Post-construction Profile and Elevation, Center Line of Pavement as Origin

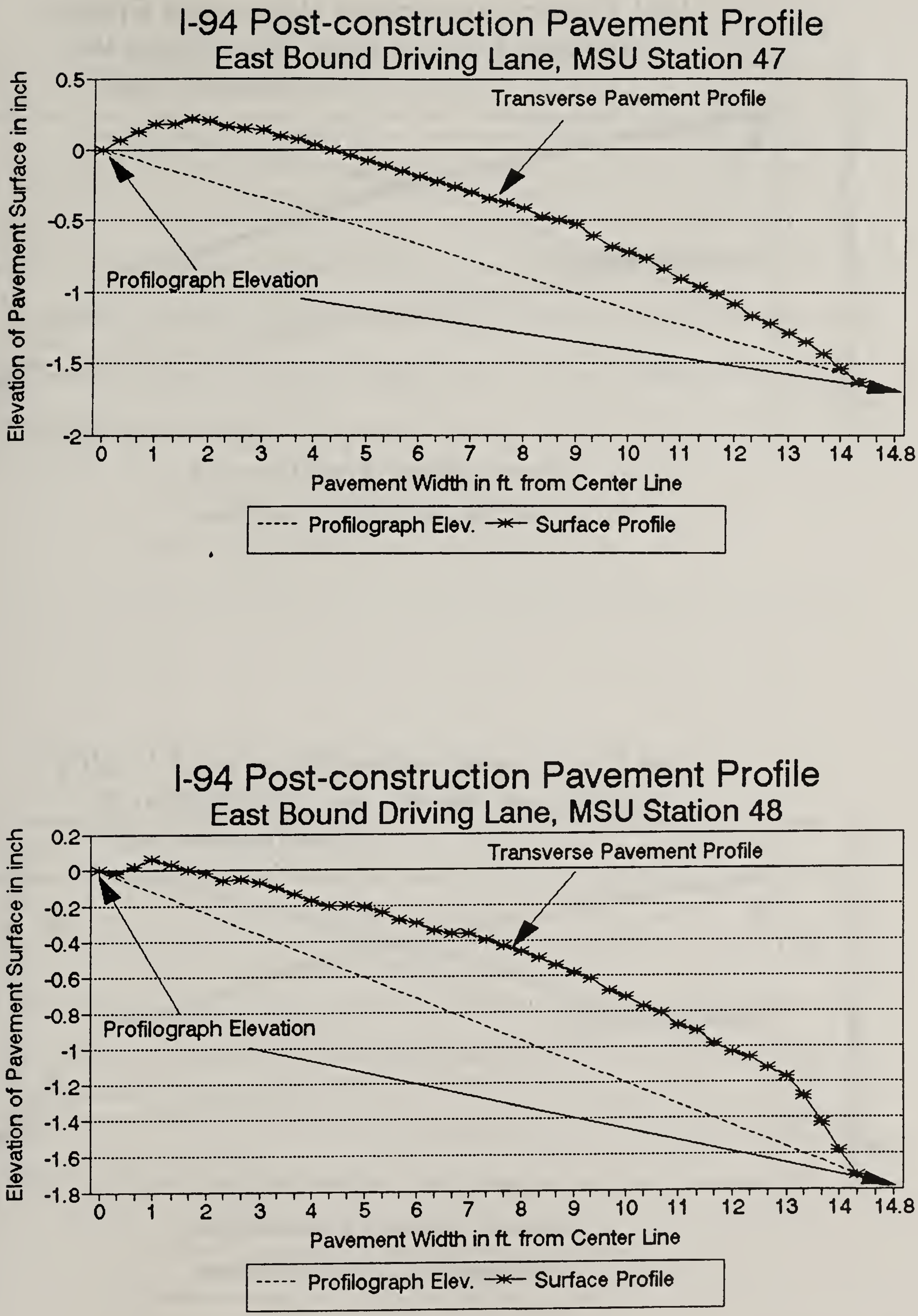
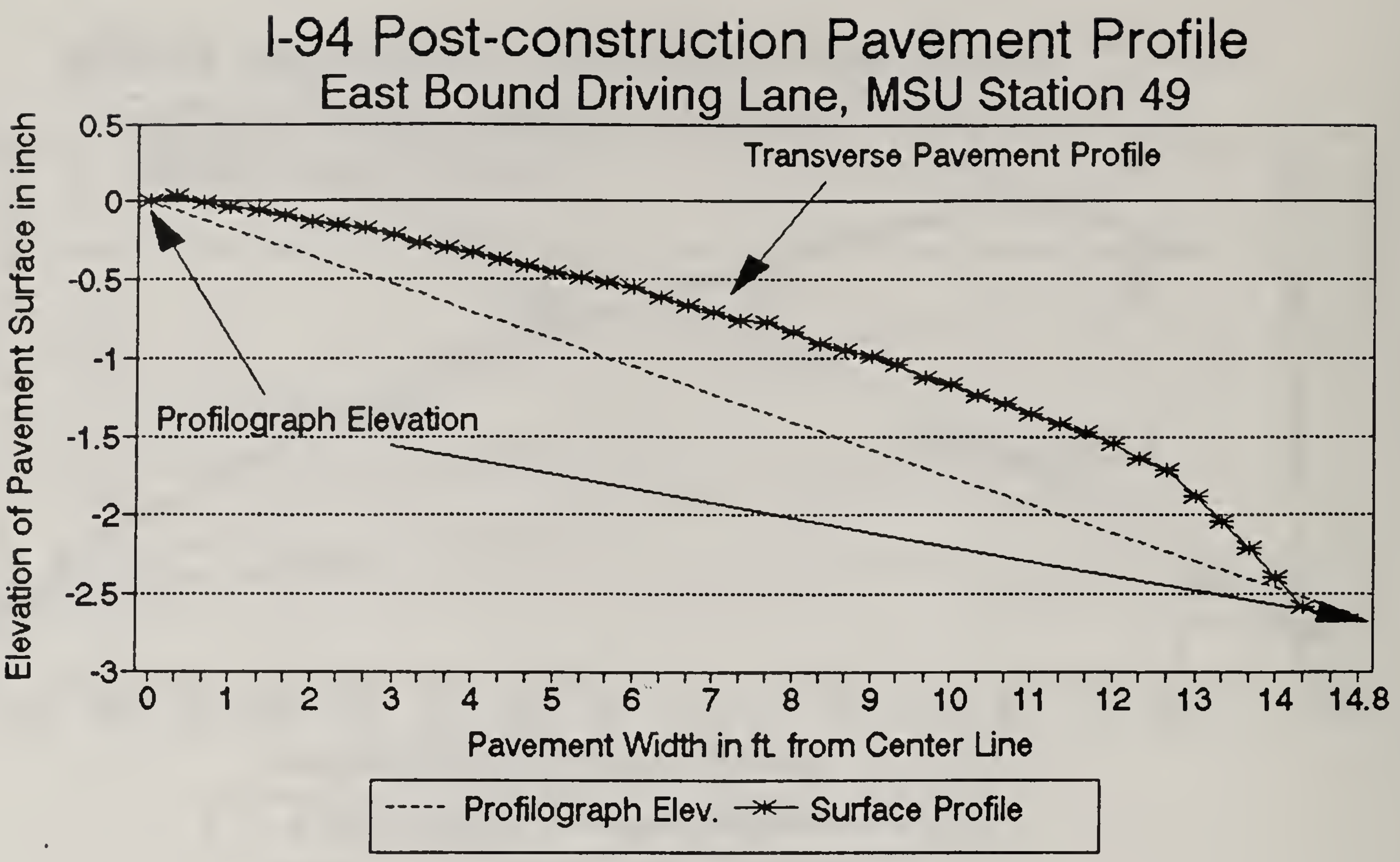


Fig. 24C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



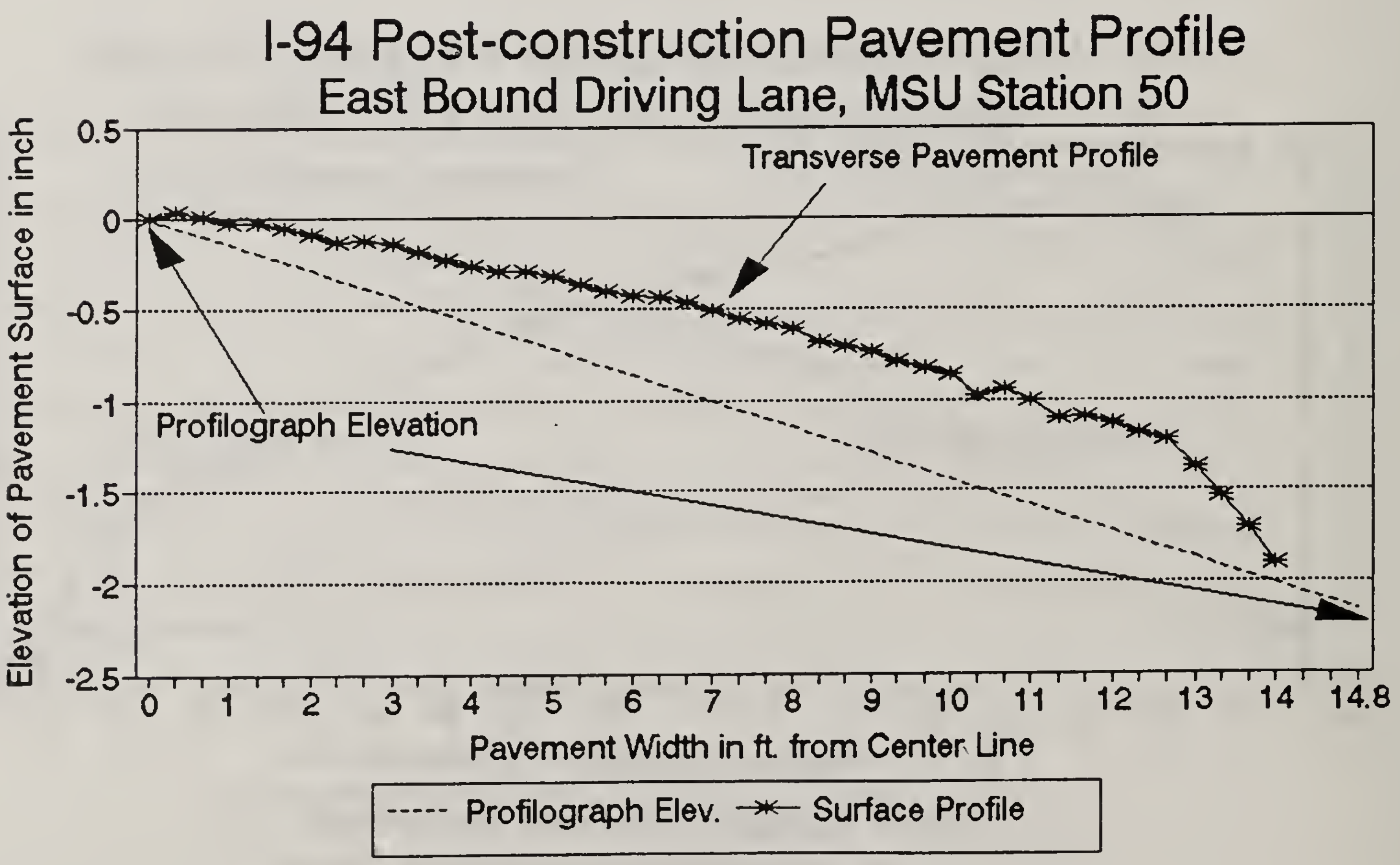
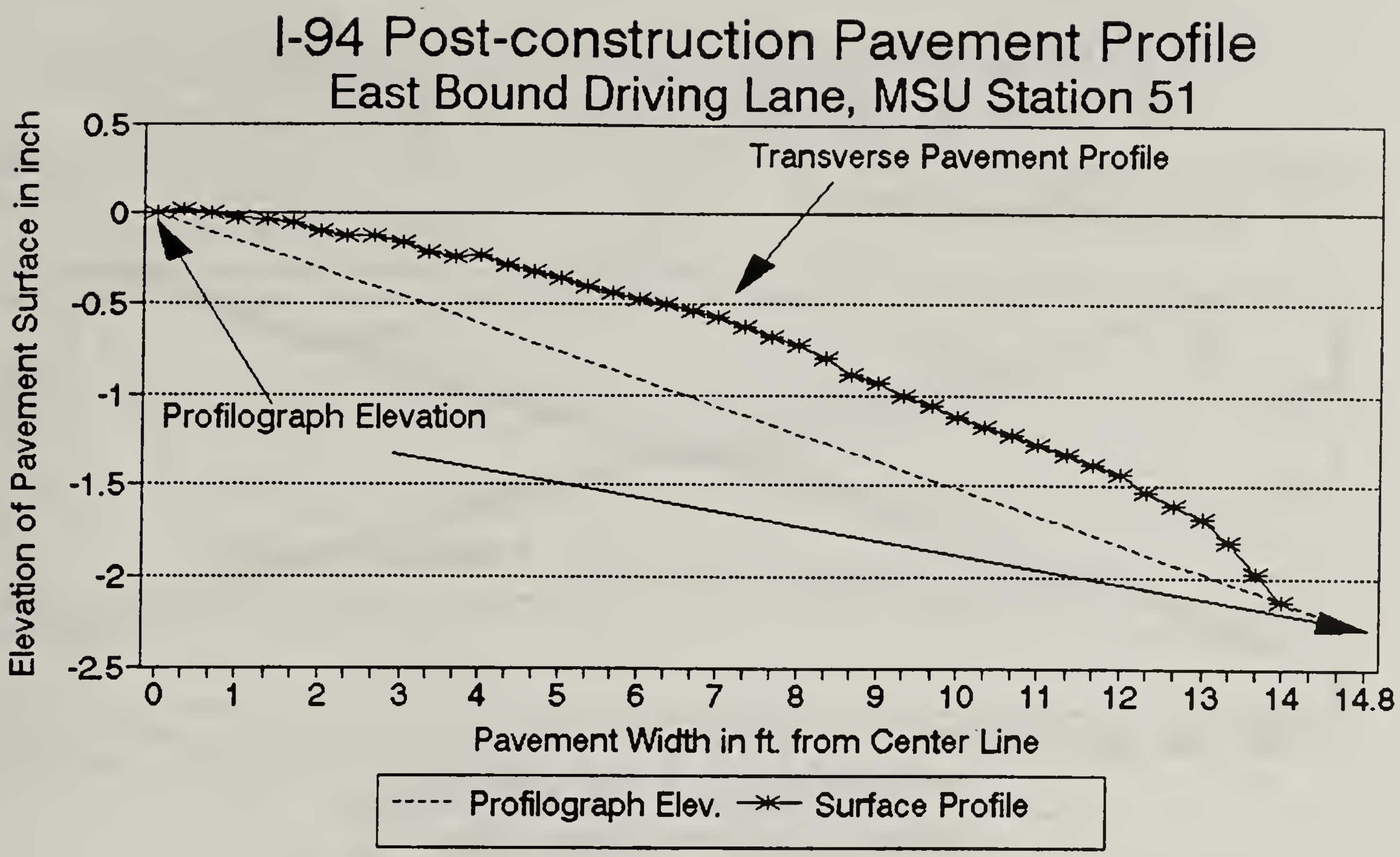


Fig. 25C. Post-construction Profile and Elevation, Center Line of Pavement as Origin



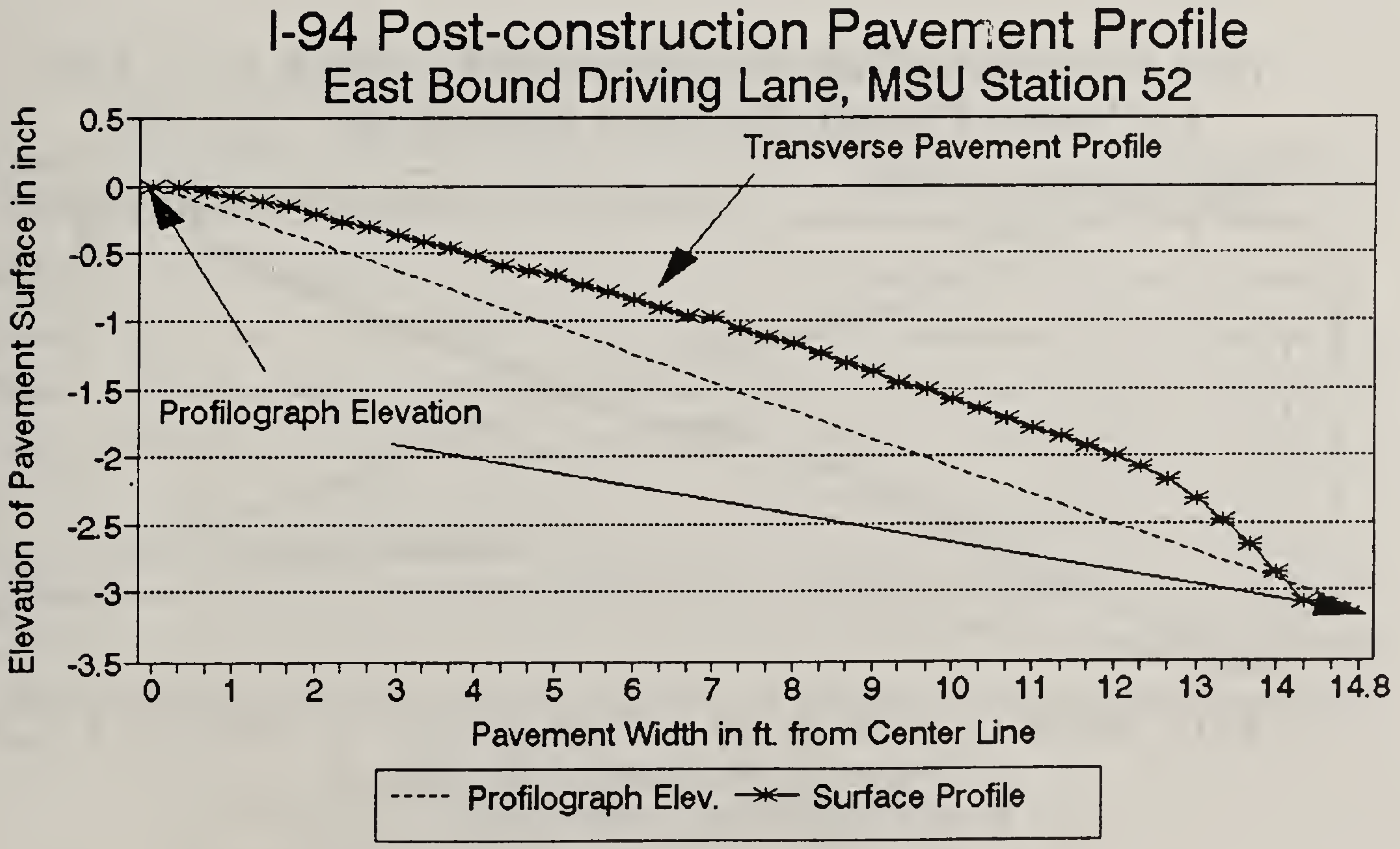
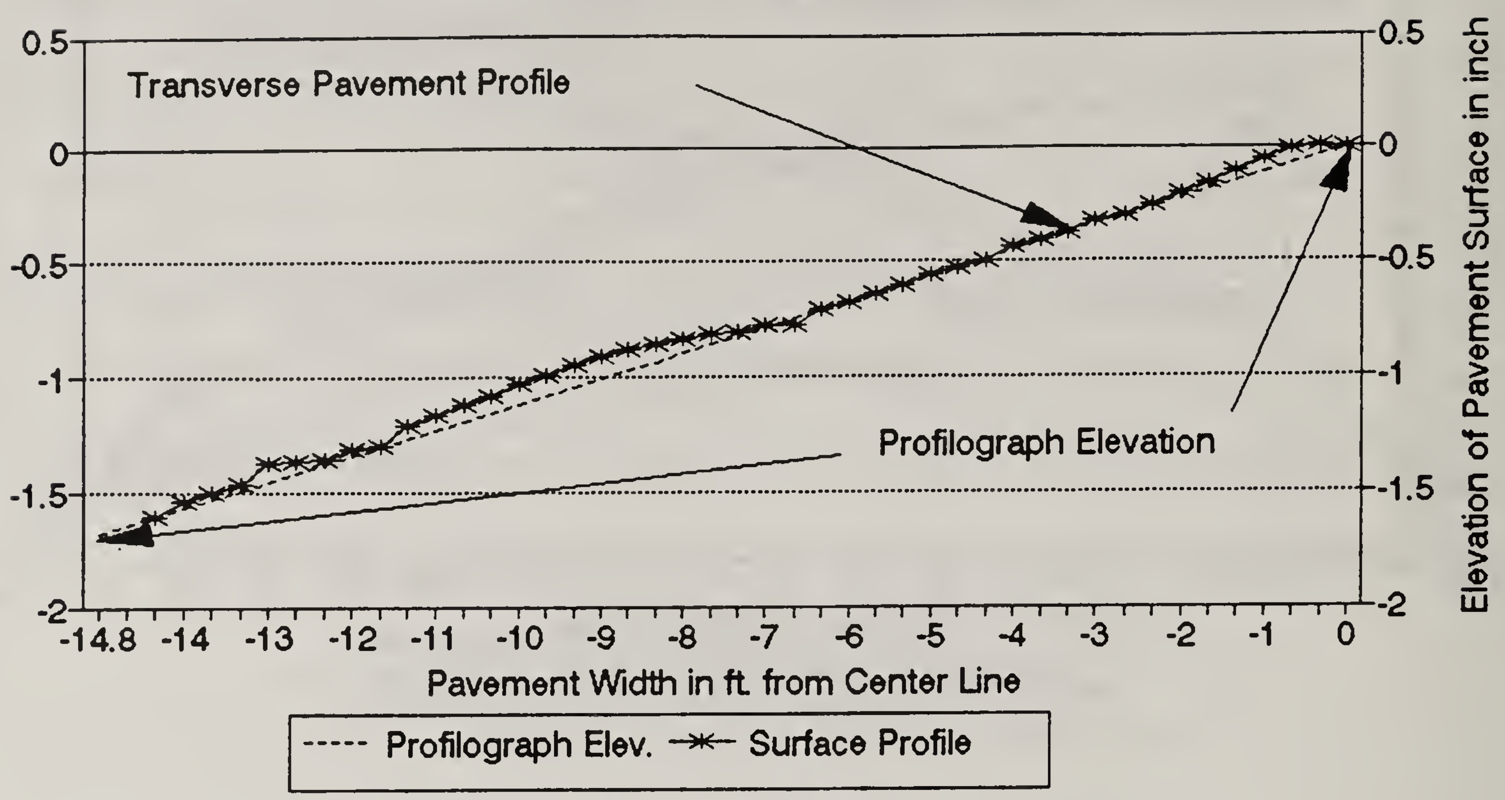
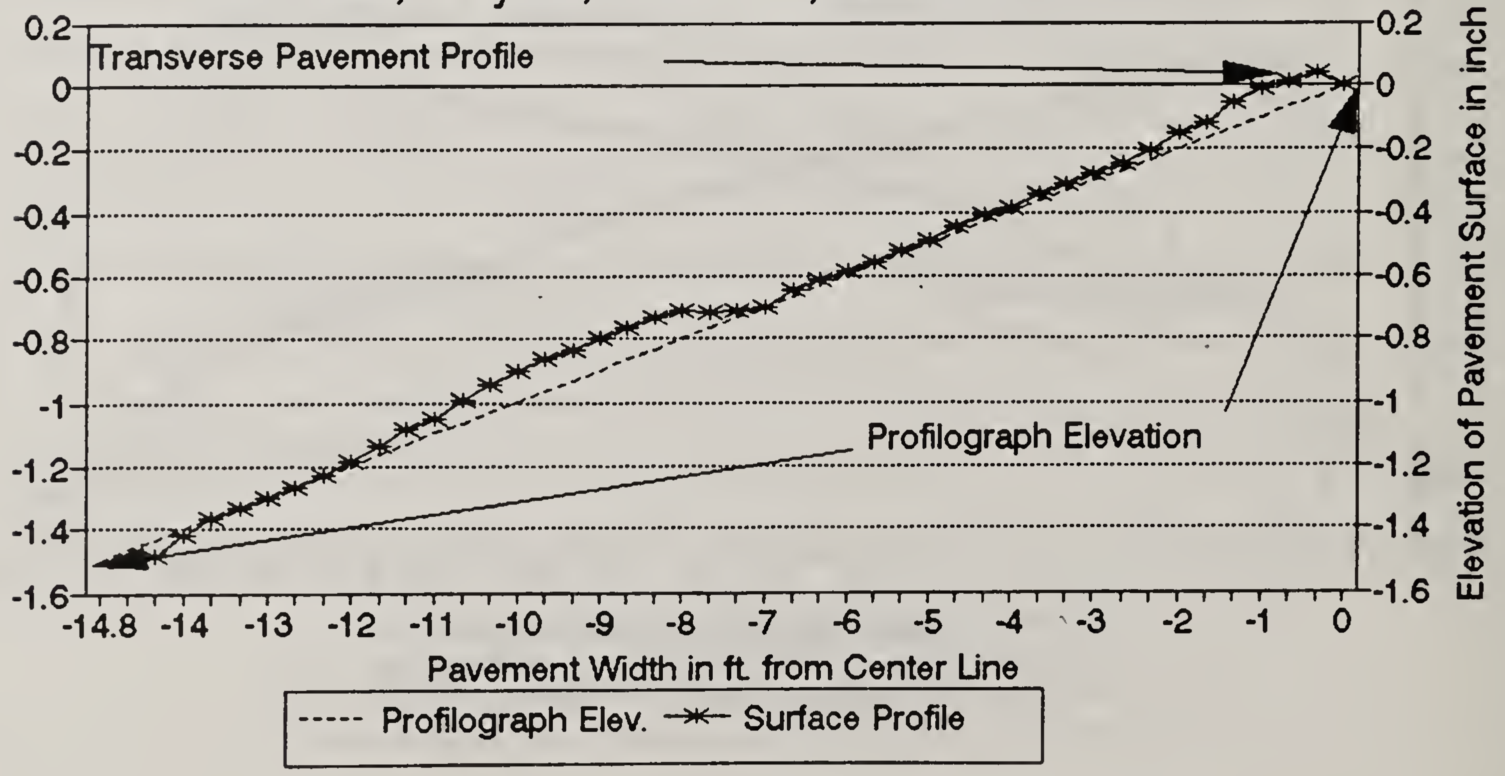


Fig.26C. Post-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Post-construction Pavement Profile

EBP Lane, Polybilt, 2130+00, MSU St. 27

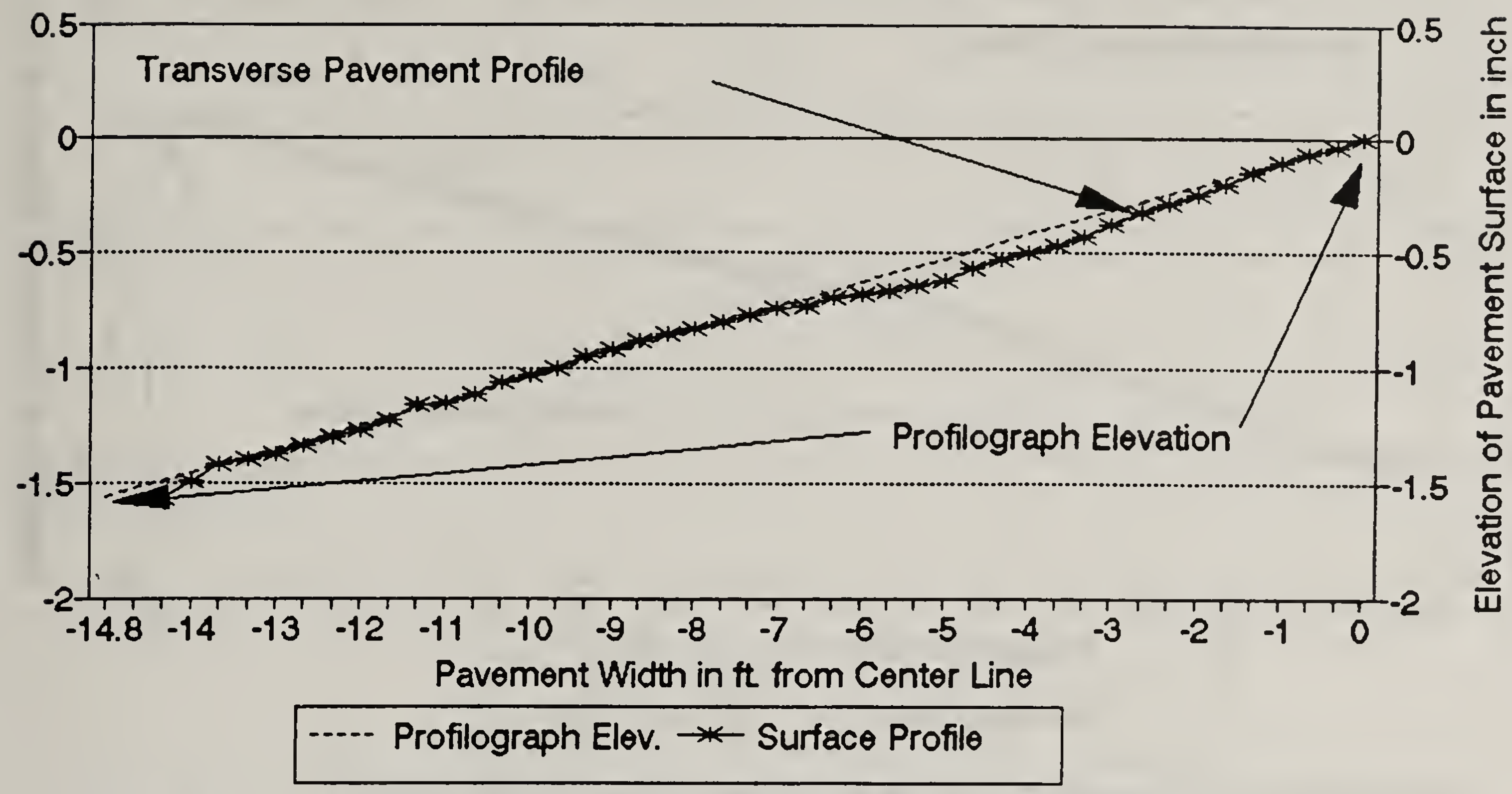
Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section


I-94 Post-construction Pavement Profile

EBP Lane, Polybilt, 2134+00, MSU St. 28

Fig. 14D. Post-construction Profile and Elevation, Center Line of Pavement as Origin

I-94 Post-construction Pavement Profile
EBP Lane, Polybilt, 2138+00, MSU St. 29



Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section

I-94 Post-construction Pavement Profile
EBP Lane, Polybilt, 2144+00, MSU St. 30

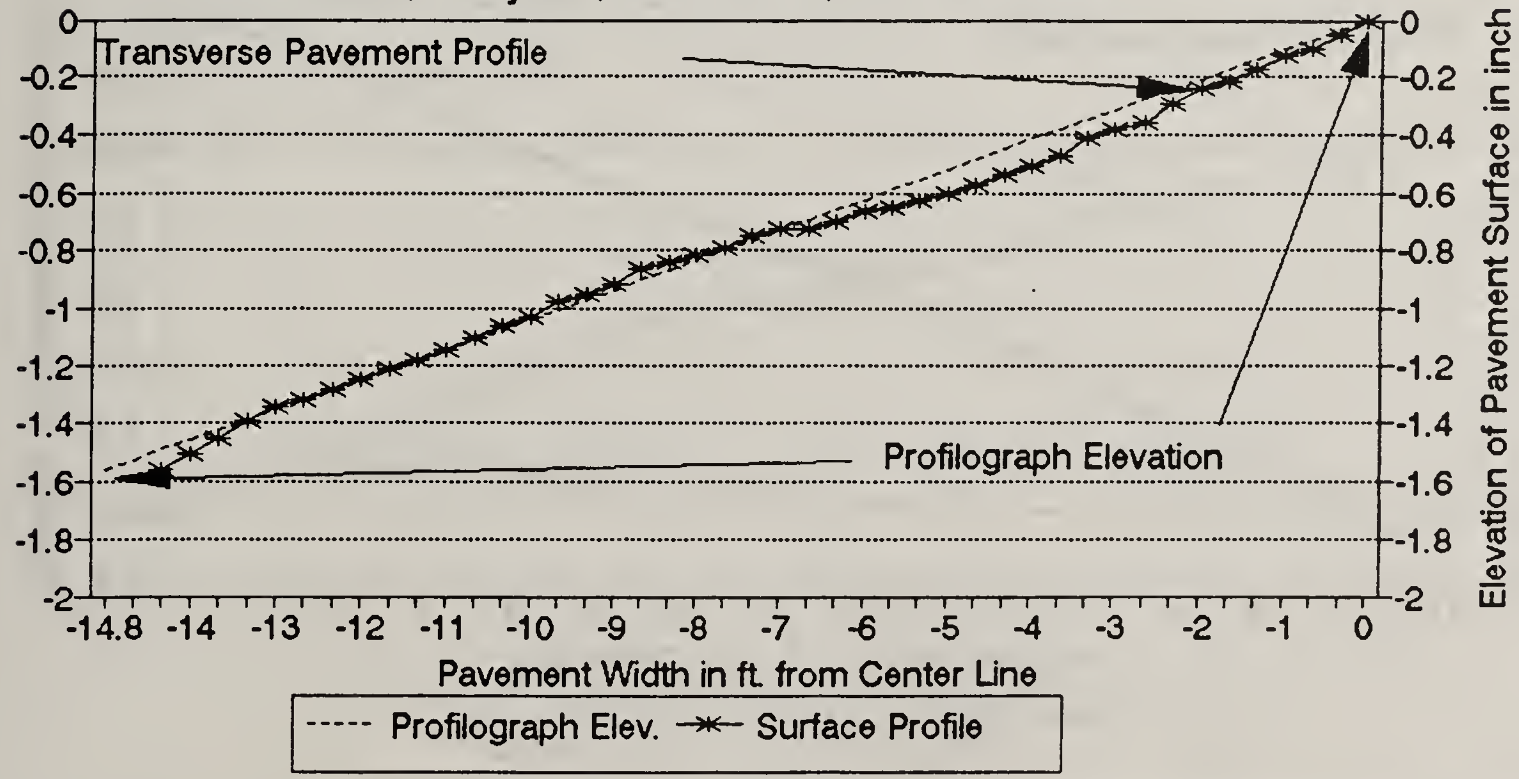
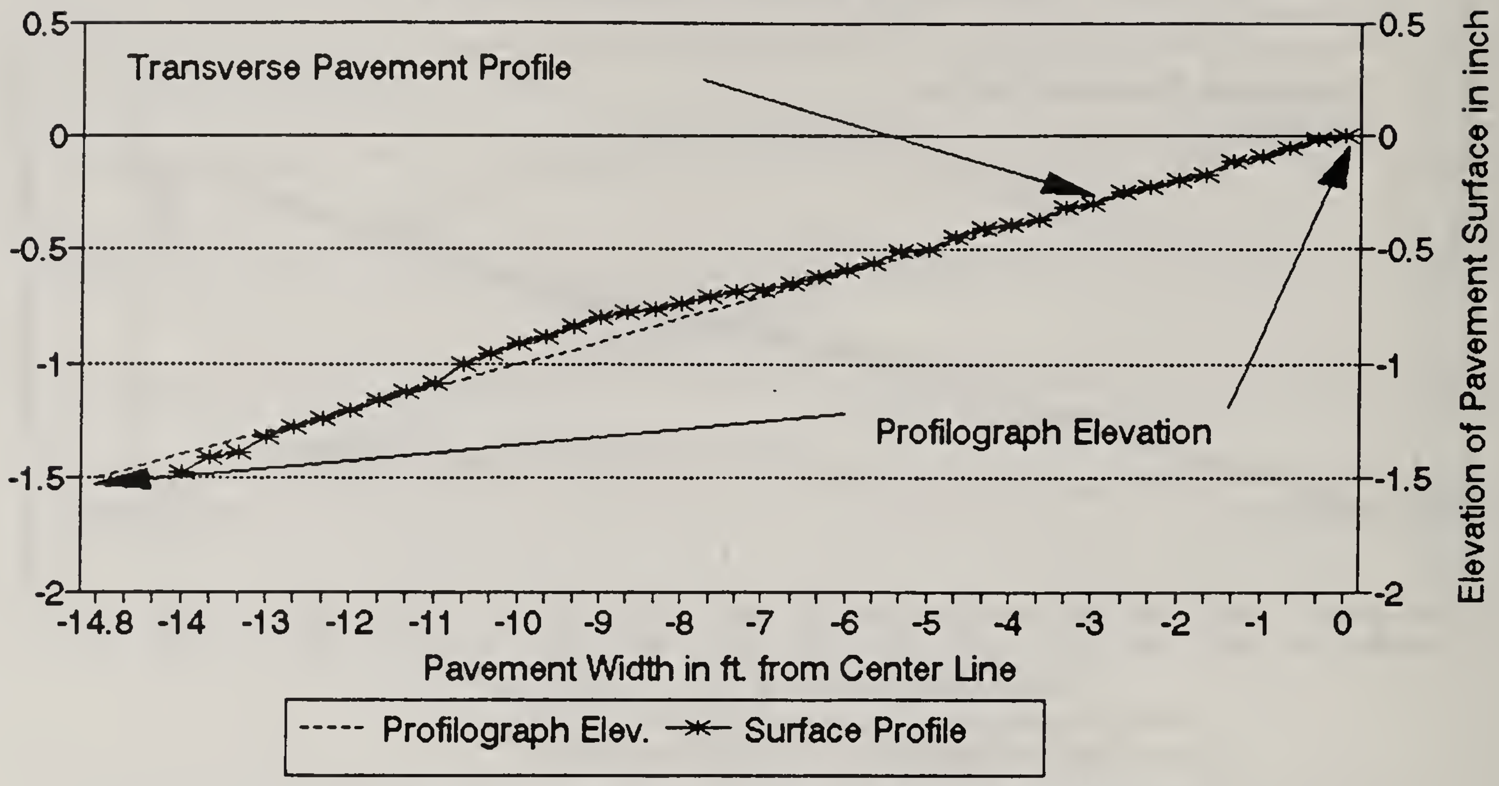


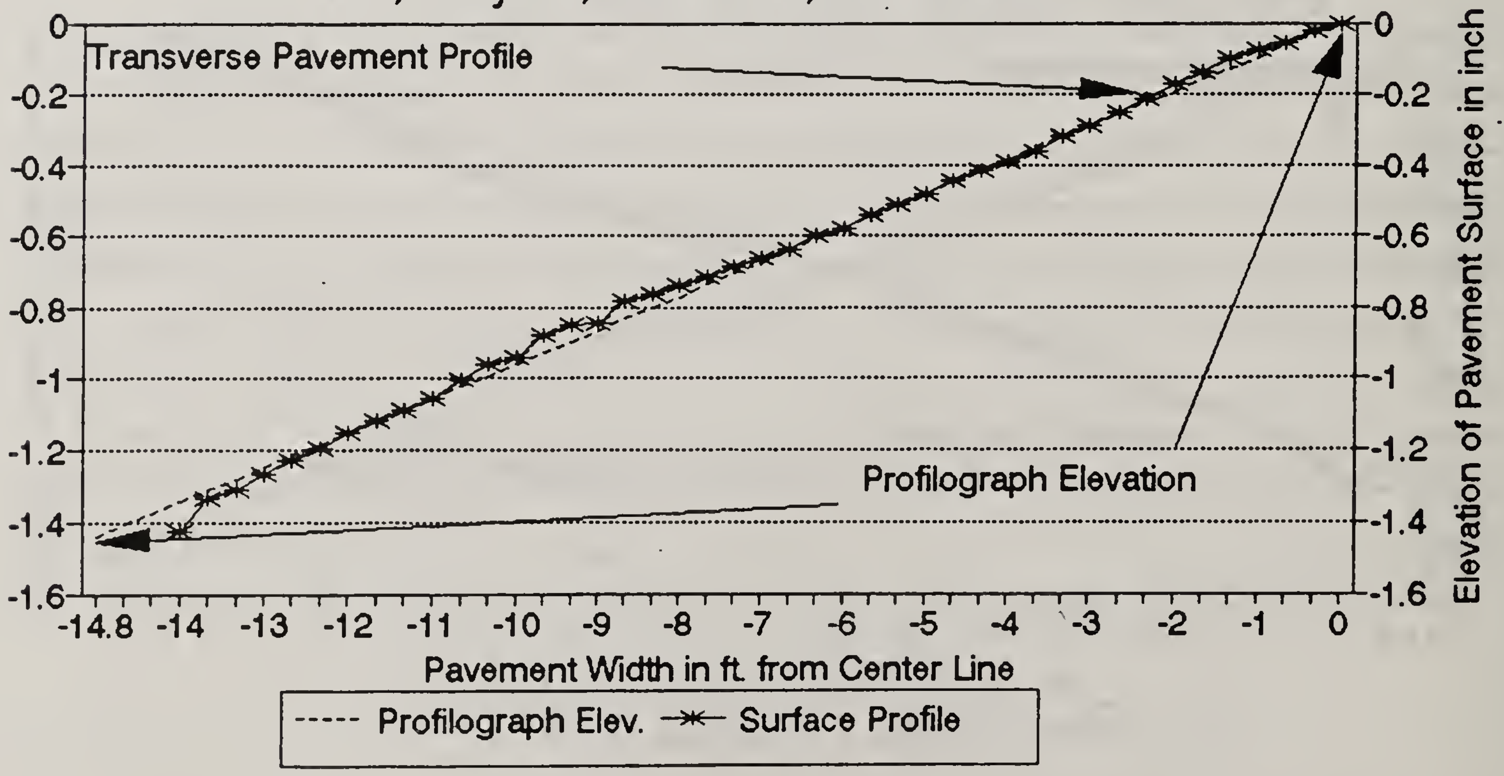
Fig. 15D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



I-94 Post-construction Pavement Profile

EBP Lane, Polybilt, 2150+00, MSU St. 31

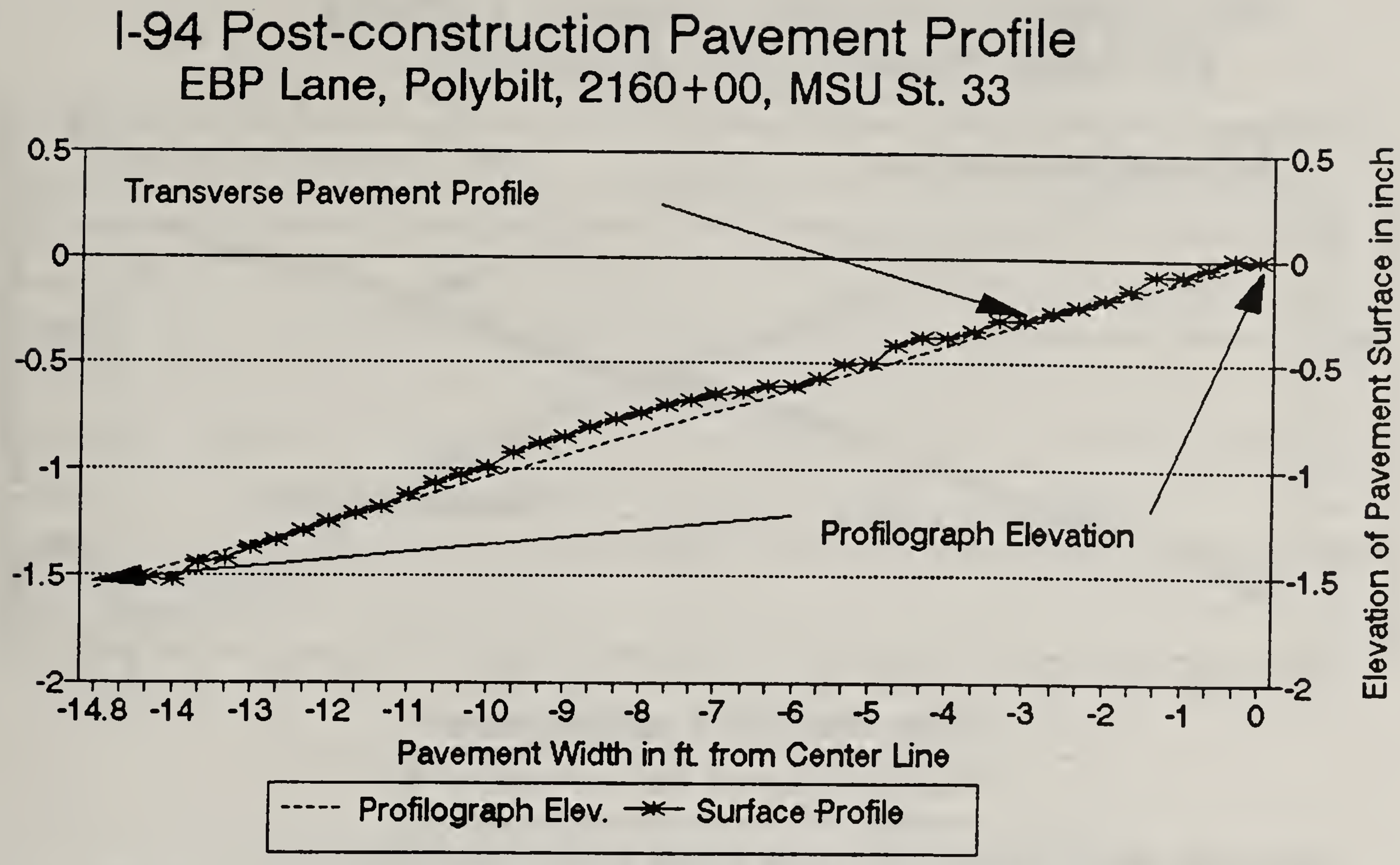
Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section



I-94 Post-construction Pavement Profile

EBP Lane, Polybilt, 2154+00, MSU St. 32

Fig. 16D. Post-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Post-construction Pavement Profile
EBP Lane, Polybilt, 2160+00, MSU St. 33

Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section

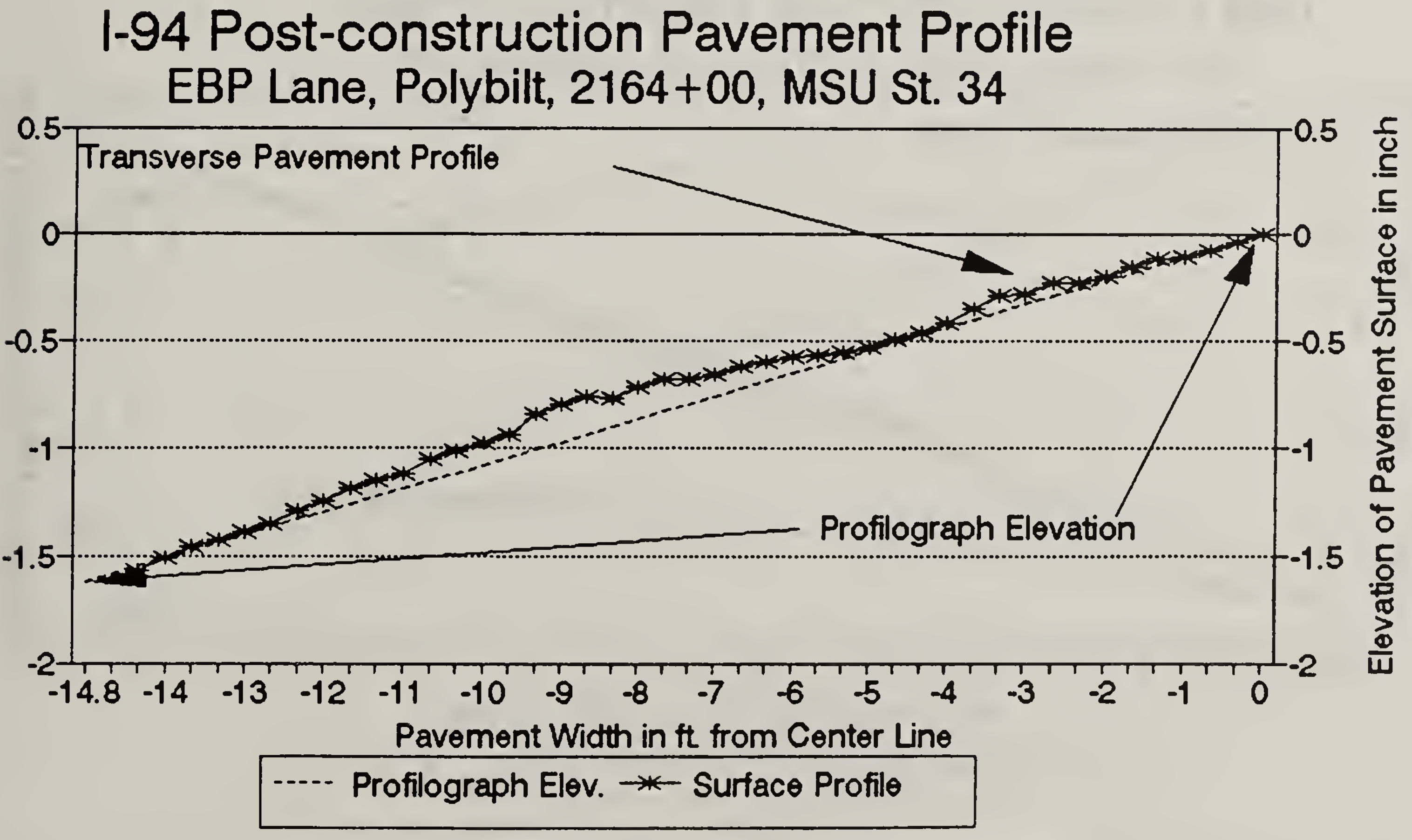
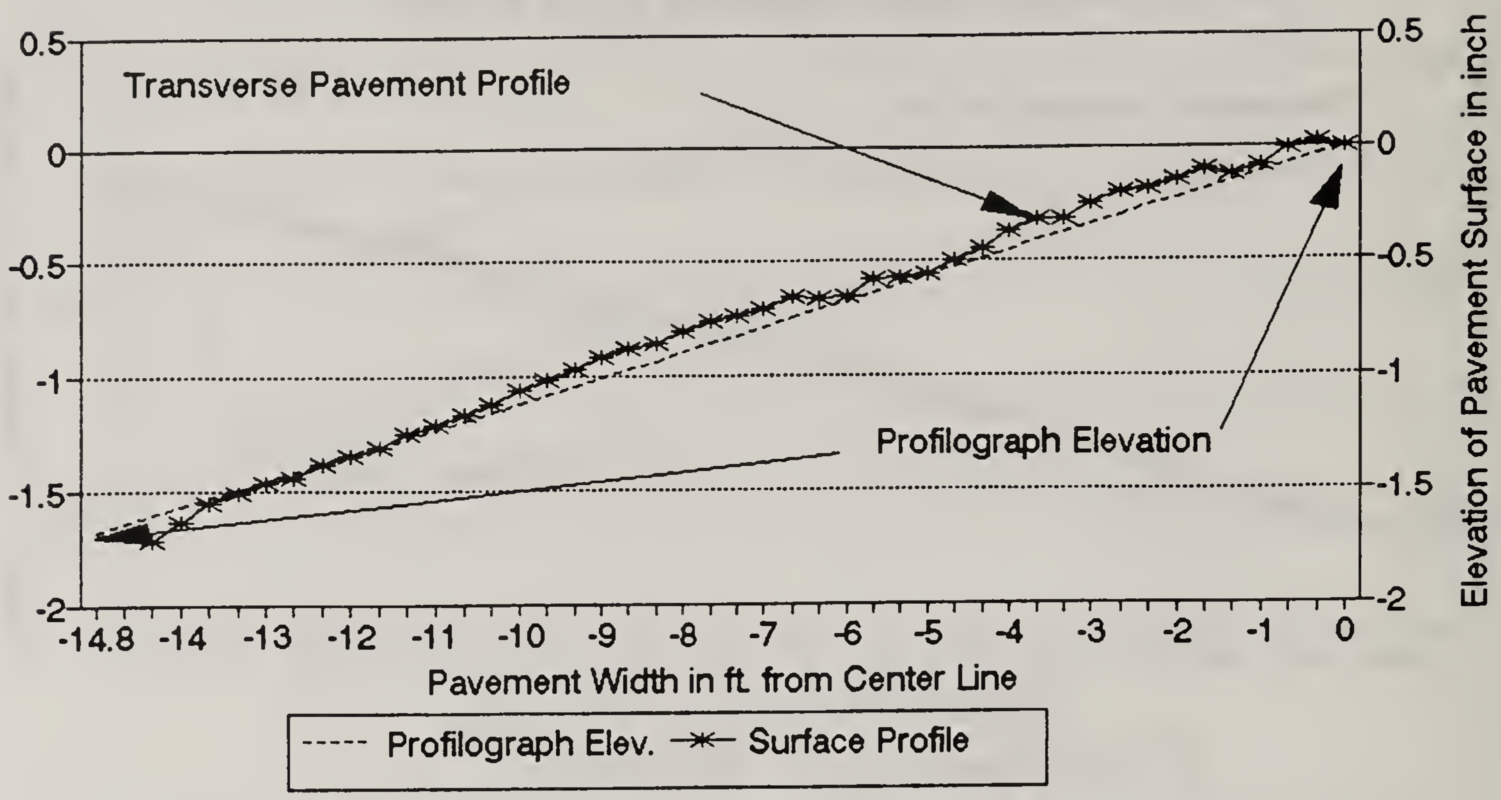

I-94 Post-construction Pavement Profile
EBP Lane, Polybilt, 2164+00, MSU St. 34

Fig. 17D. Post-construction Profile and Elevation, Center Line of Pavement as Origin


I-94 Post-construction Pavement Profile
EBP Lane, Polybilt, 2170+00, MSU St. 35

Note: East Bound Passing (EBP) Lane, Polybilt Modified Binder Section

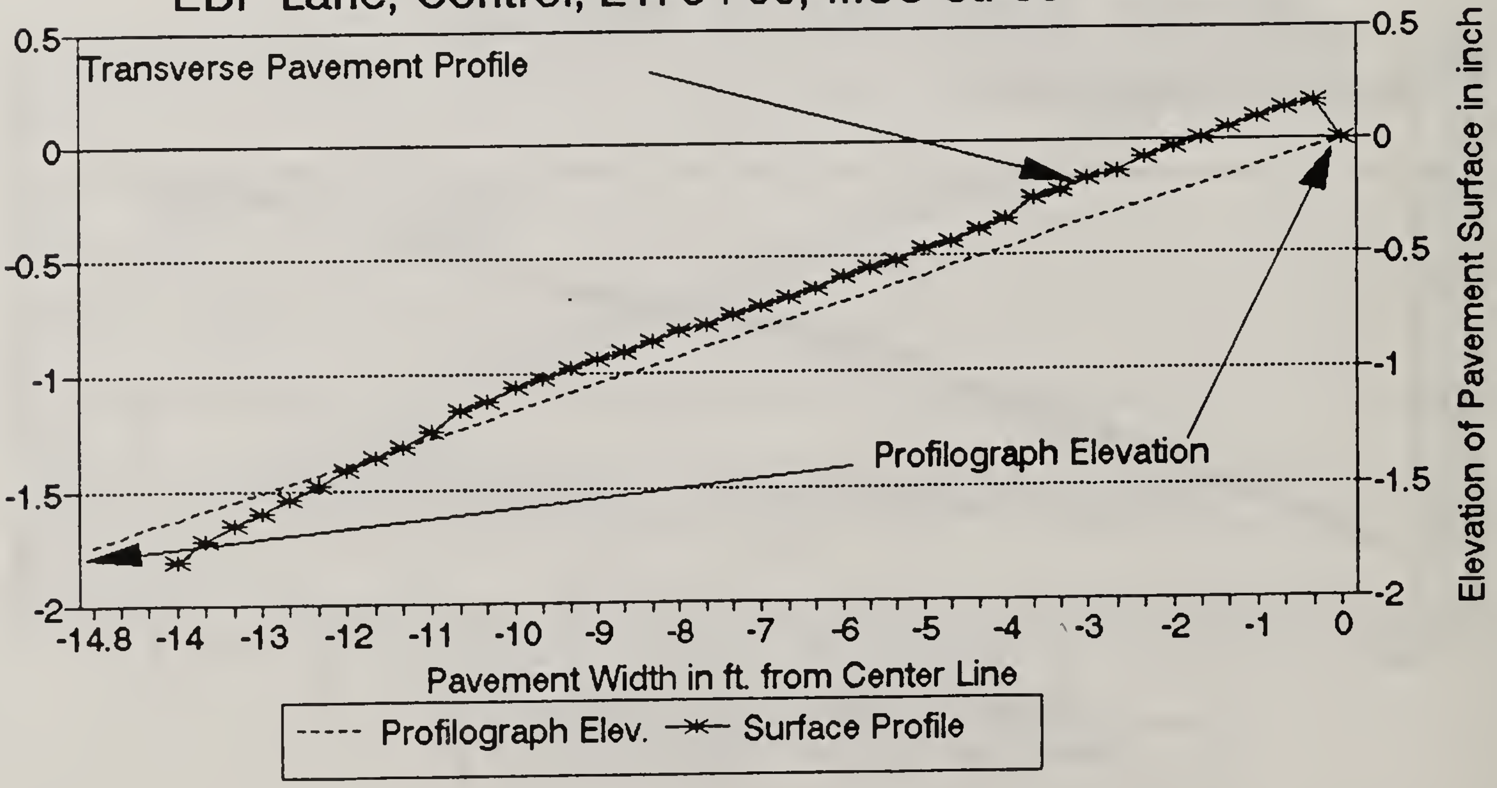
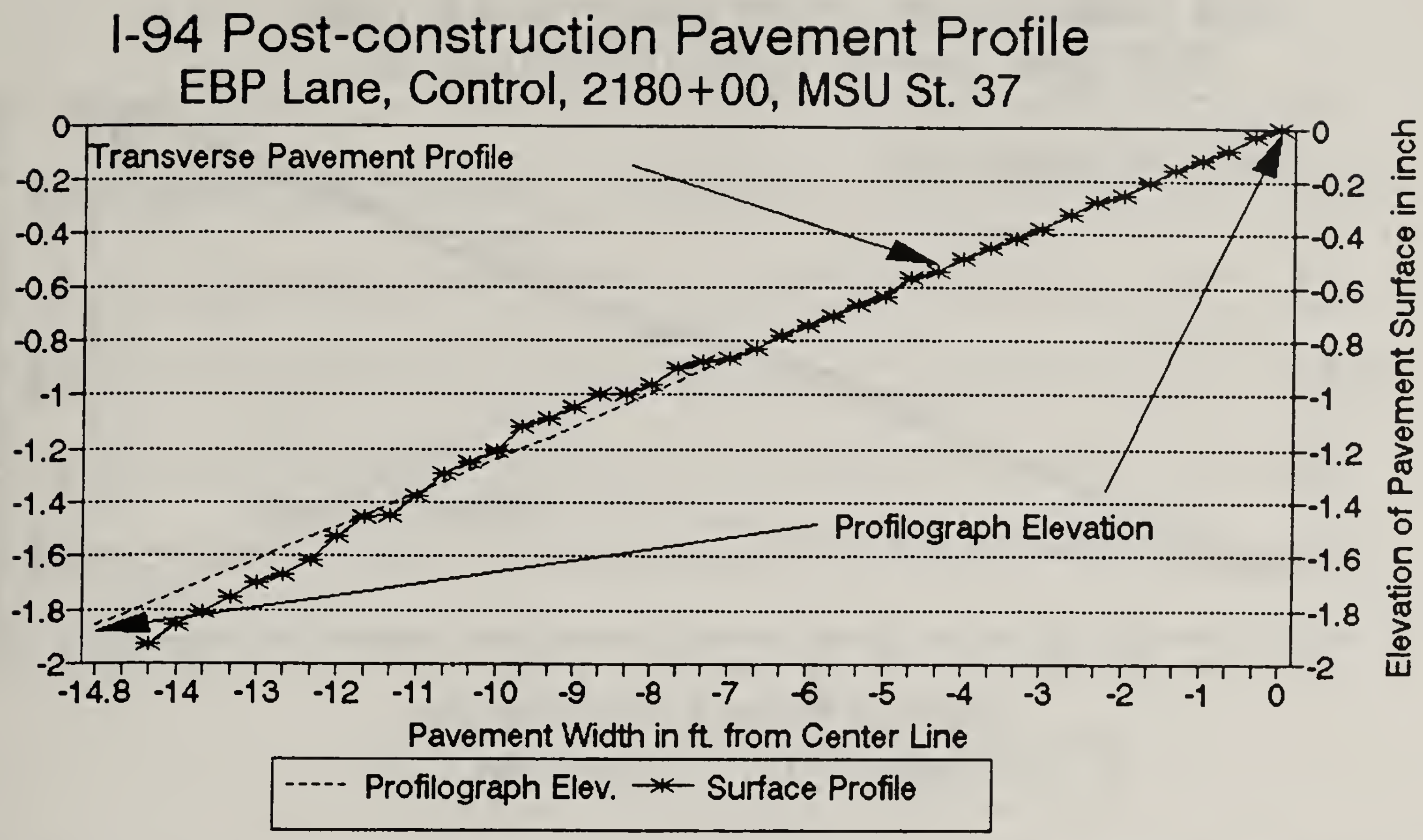

I-94 Post-construction Pavement Profile
EBP Lane, Control, 2176+00, MSU St. 36

Fig. 18D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Control Section - Unmodified Exxon Binder

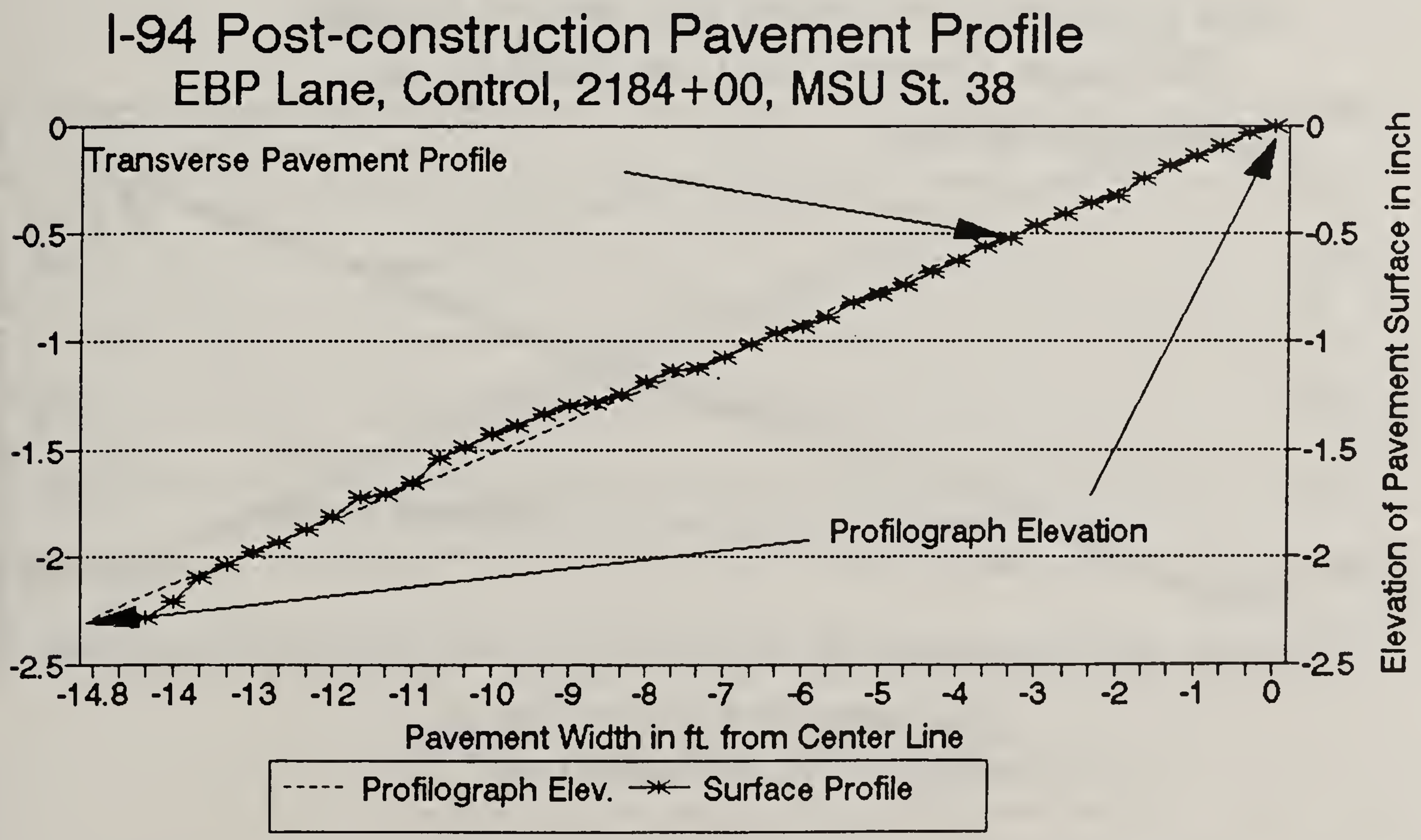
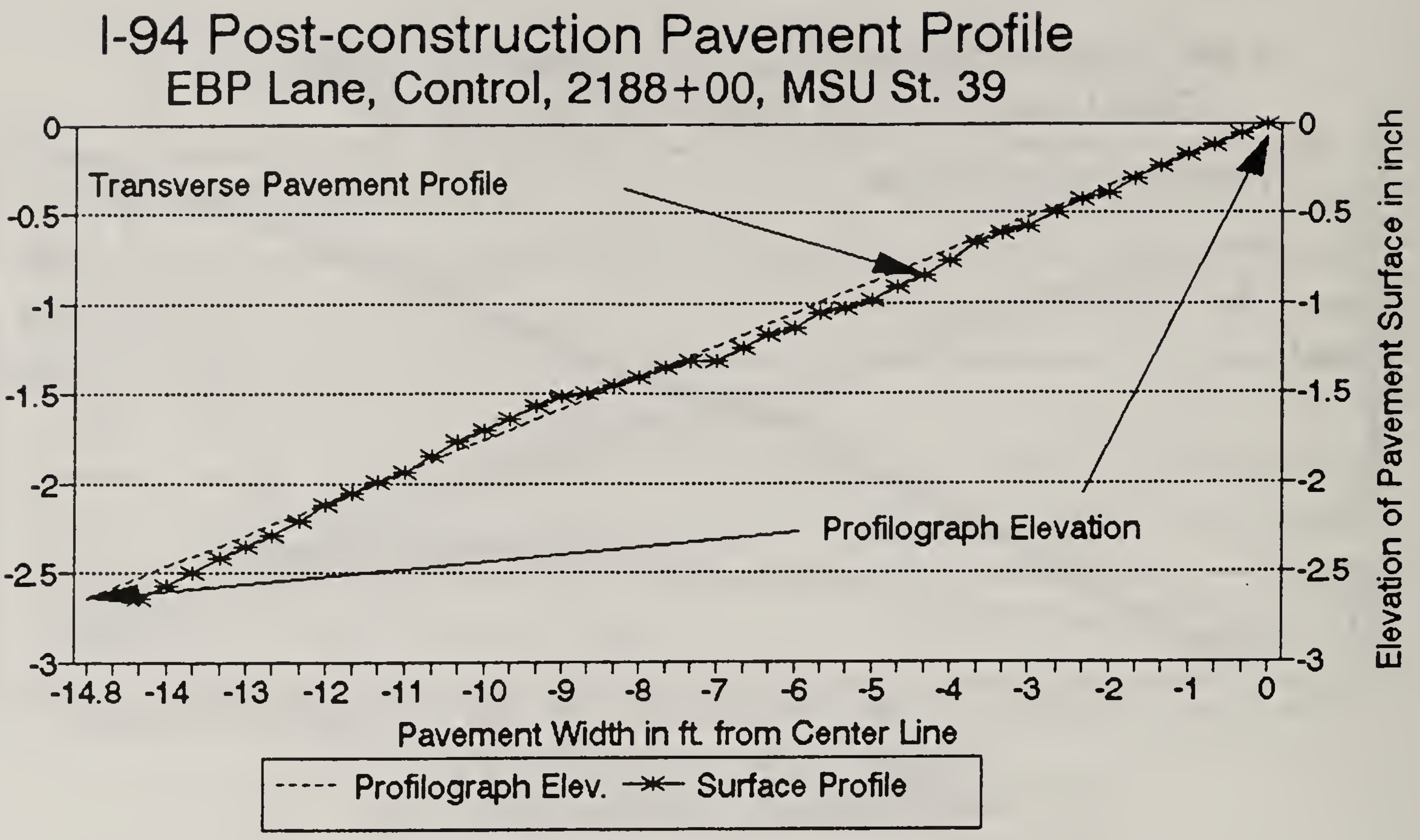


Fig. 19D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Control Section - Unmodified Exxon Binder

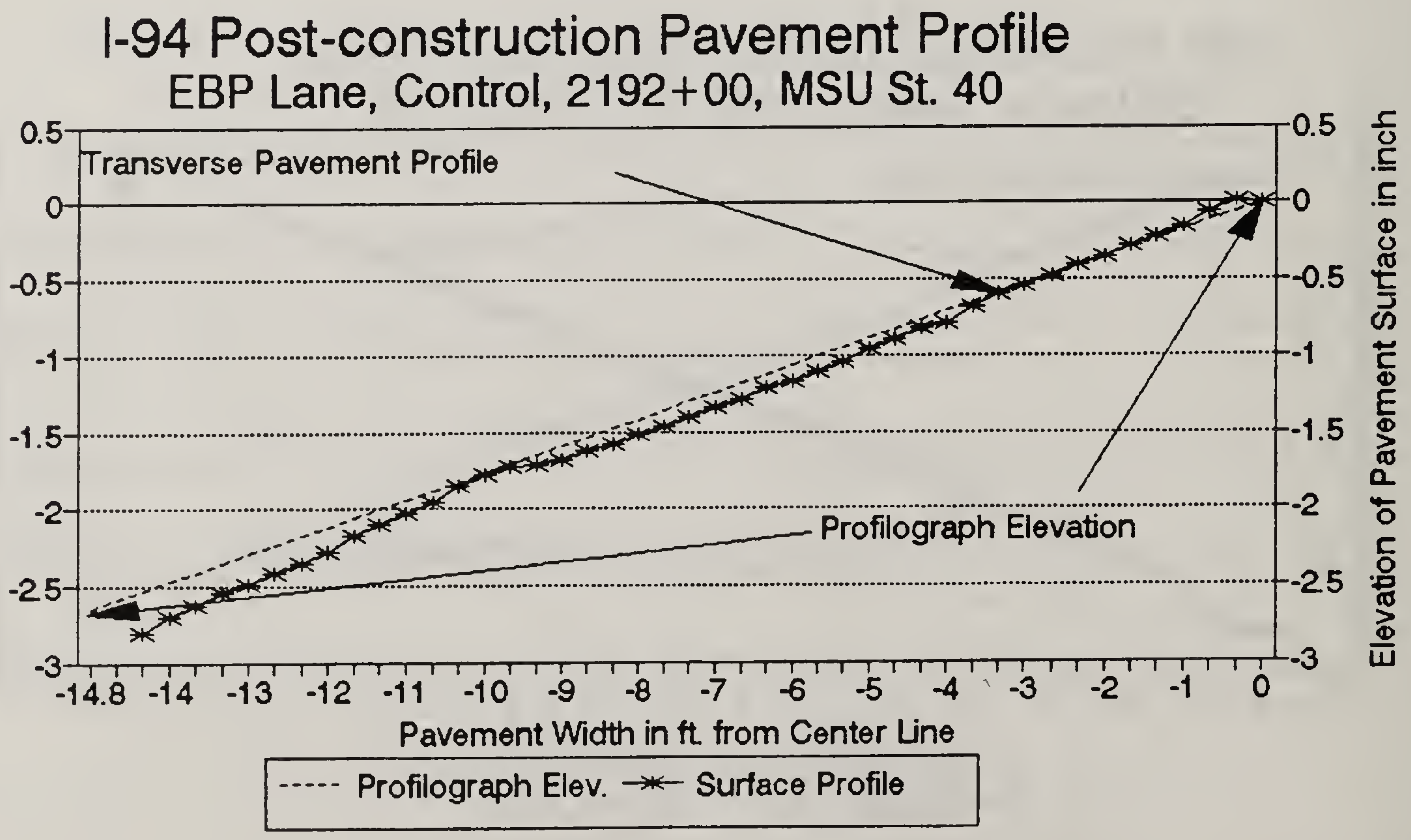
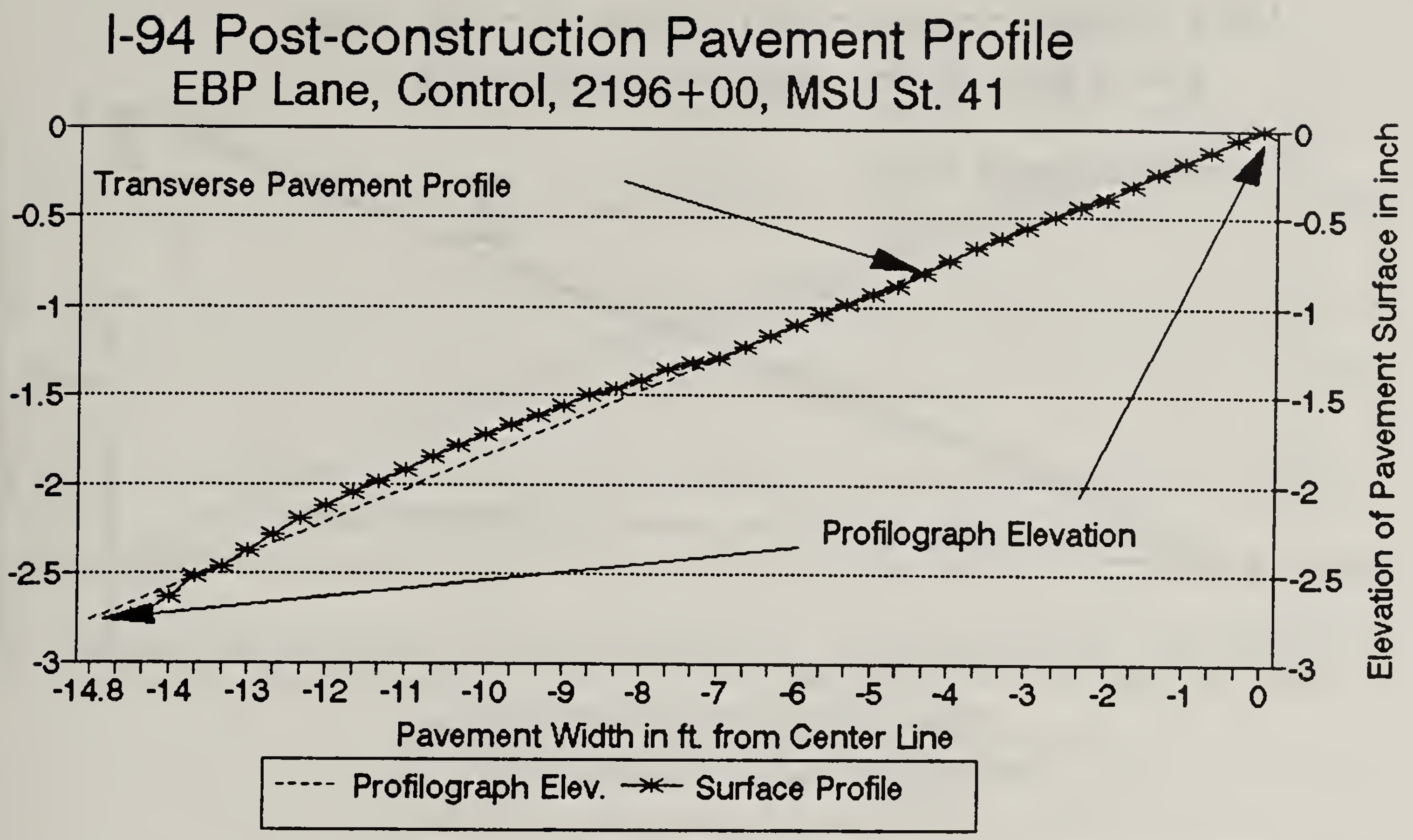


Fig. 20D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Control Section - Unmodified Exxon Binder

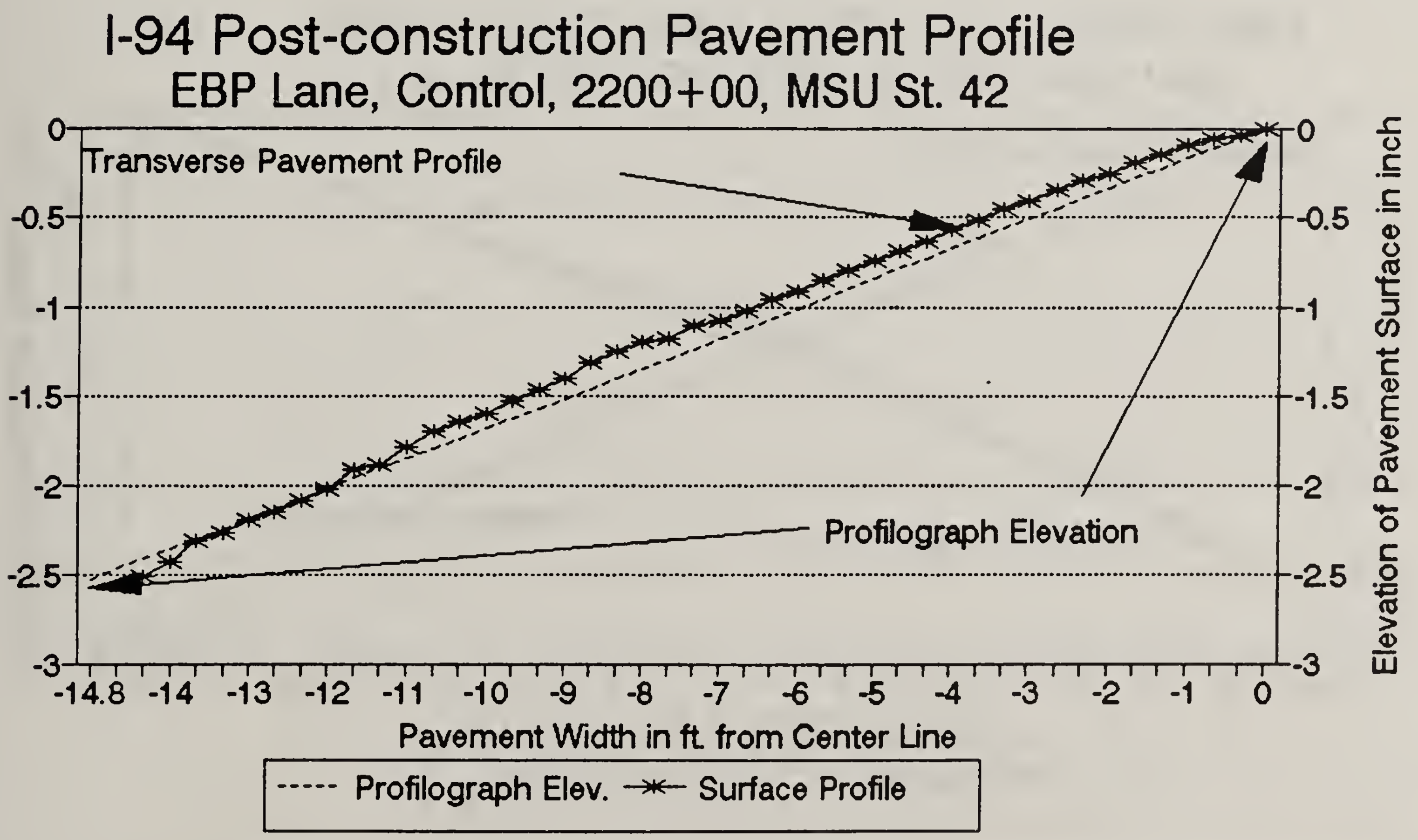
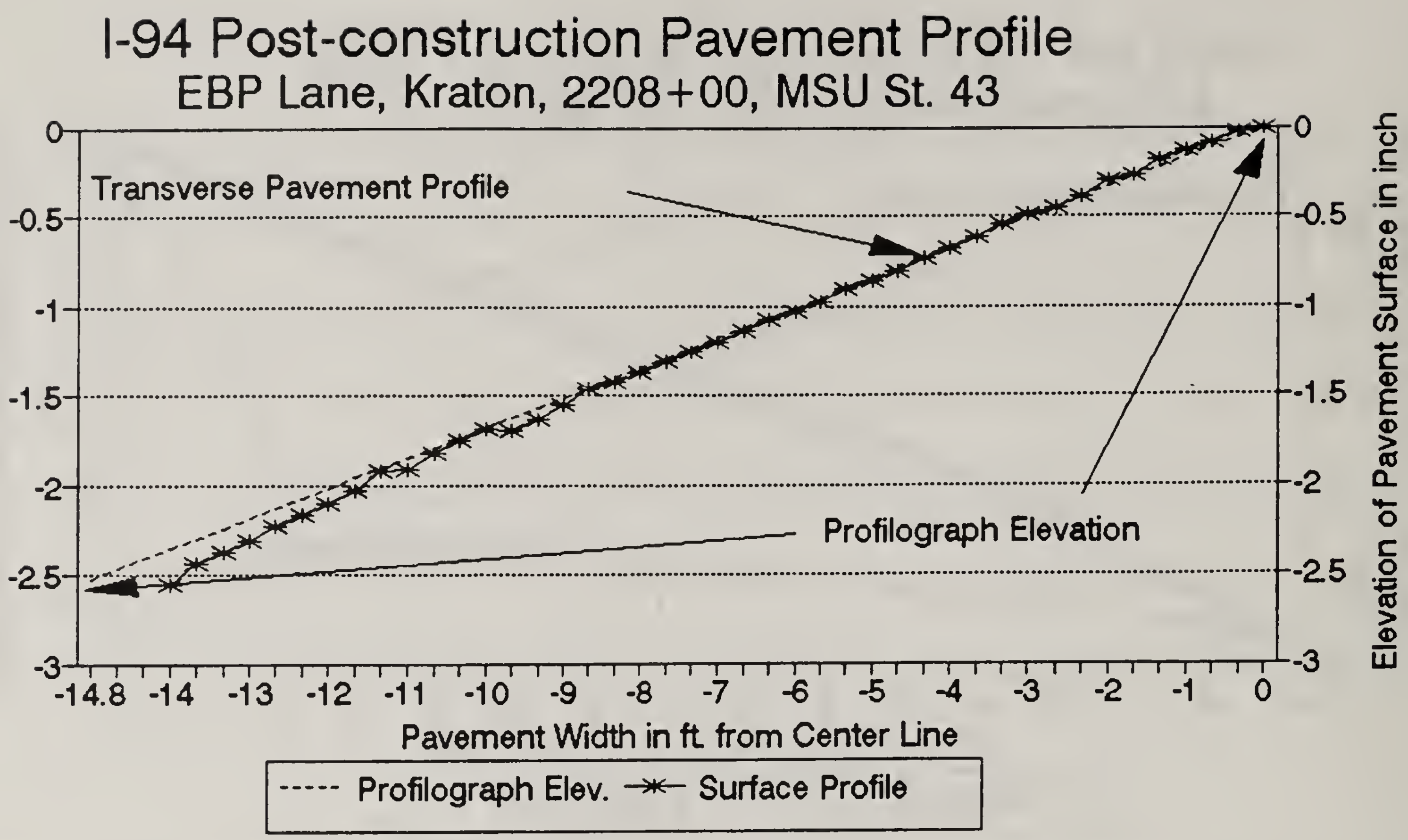


Fig. 21D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Kraton Modified Binder

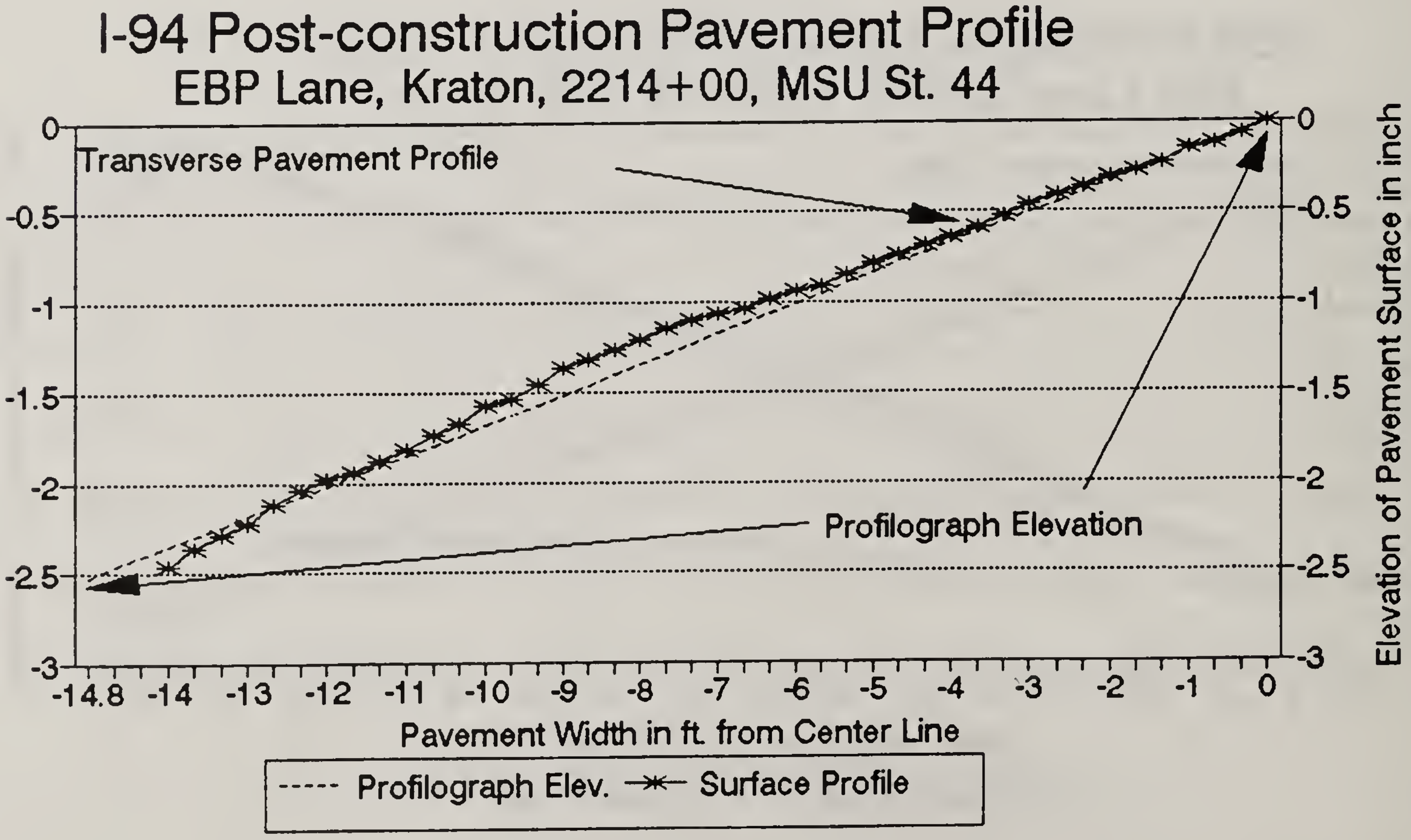
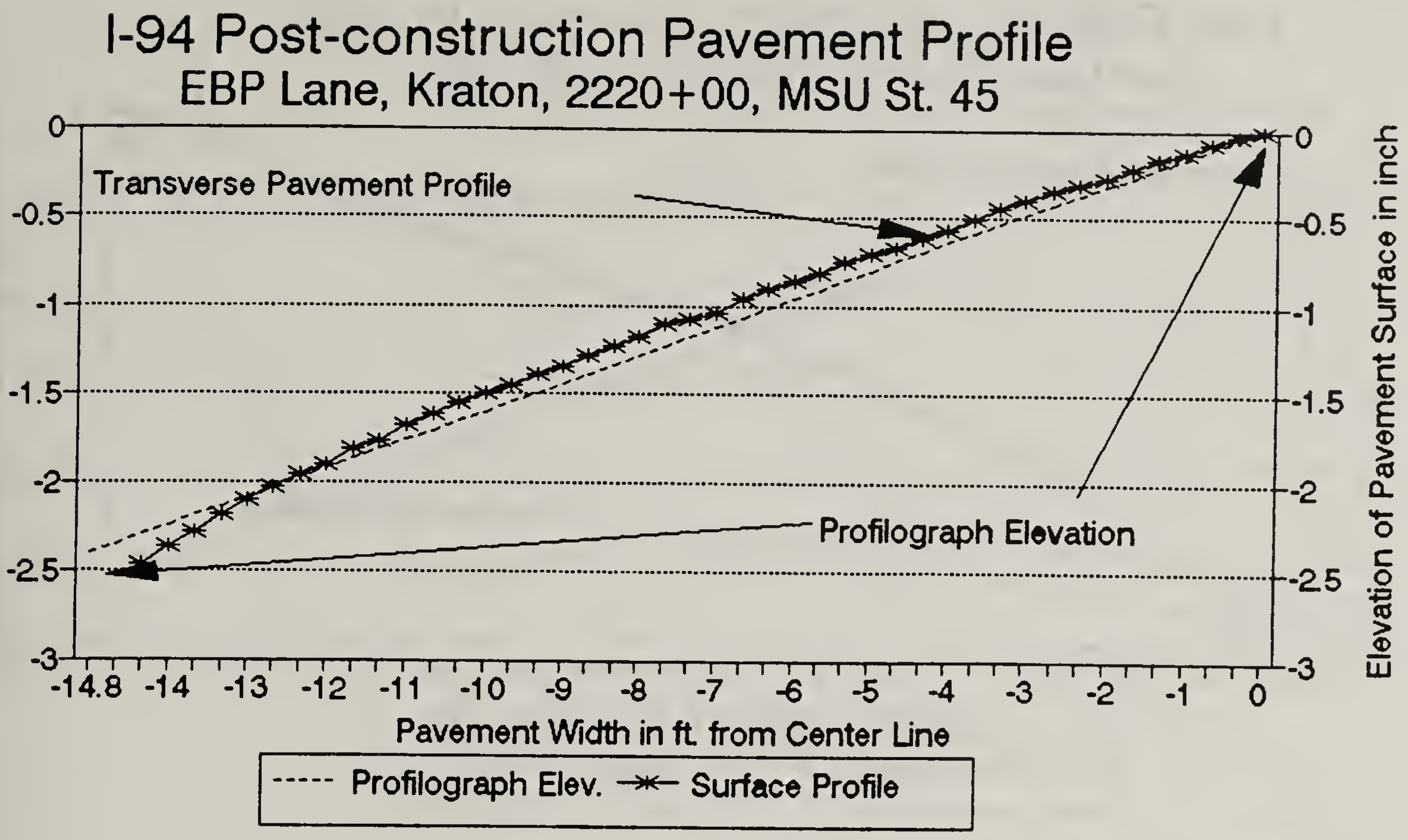


Fig. 22D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



Note: East Bound Passing (EBP) Lane, Kraton Modified Binder

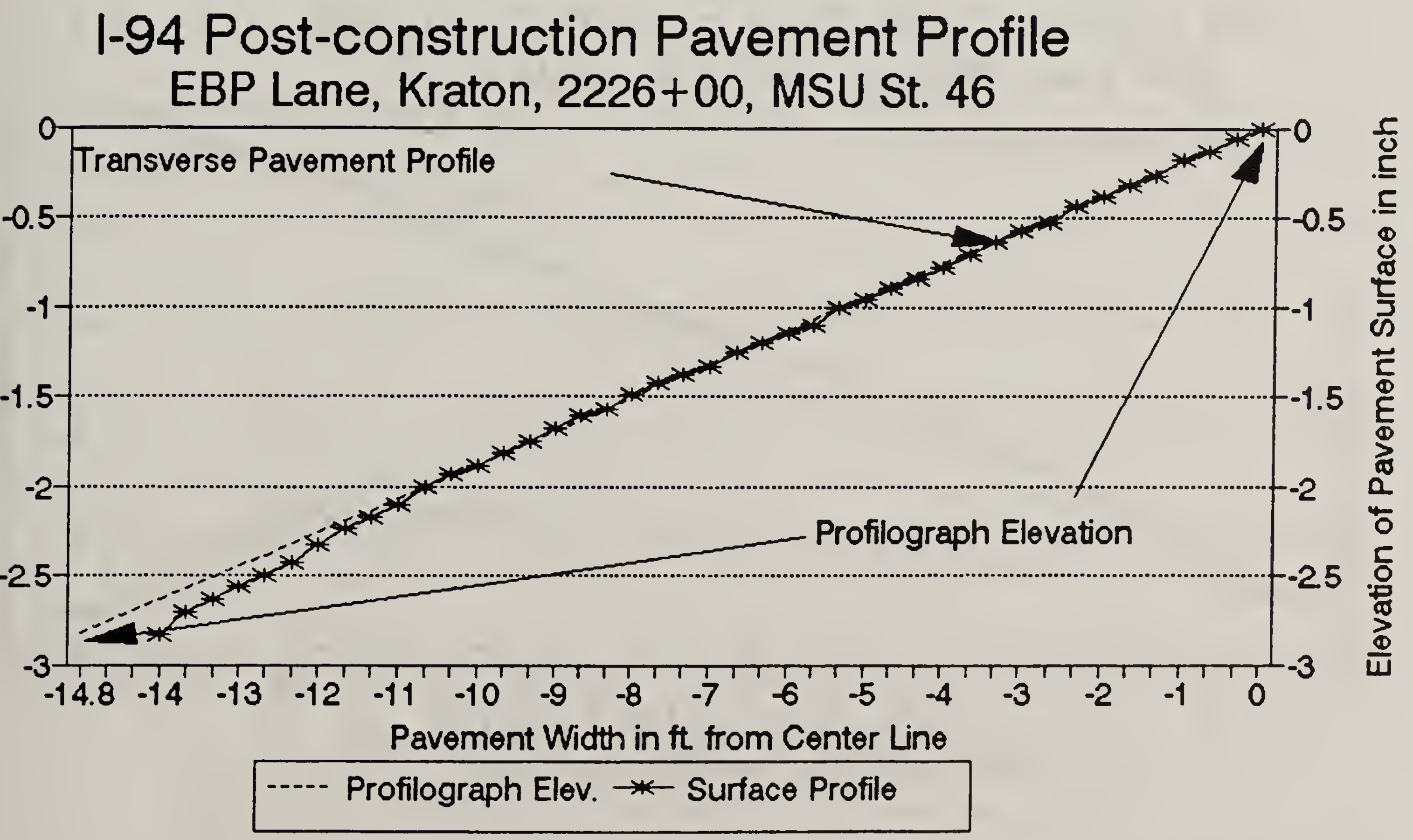
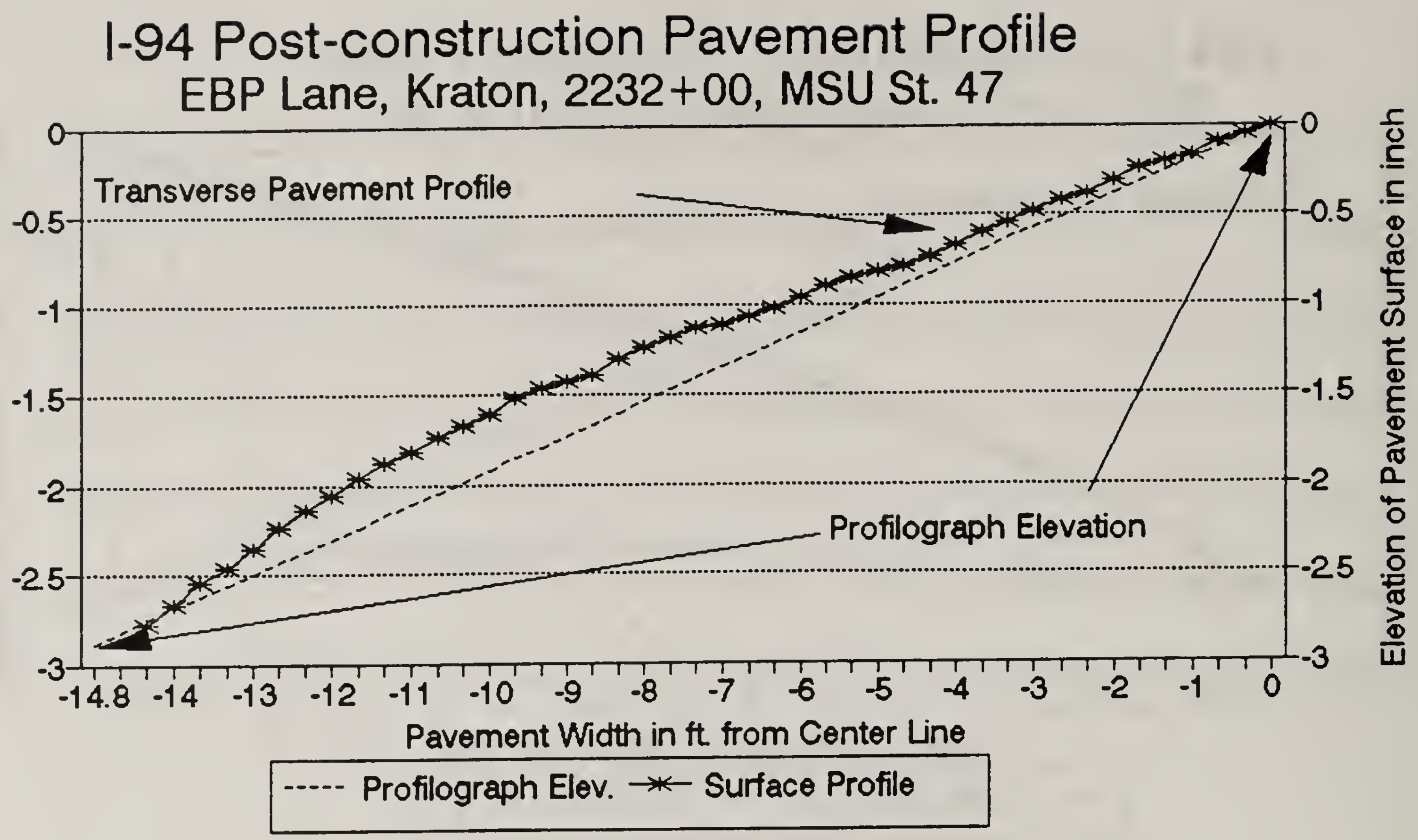
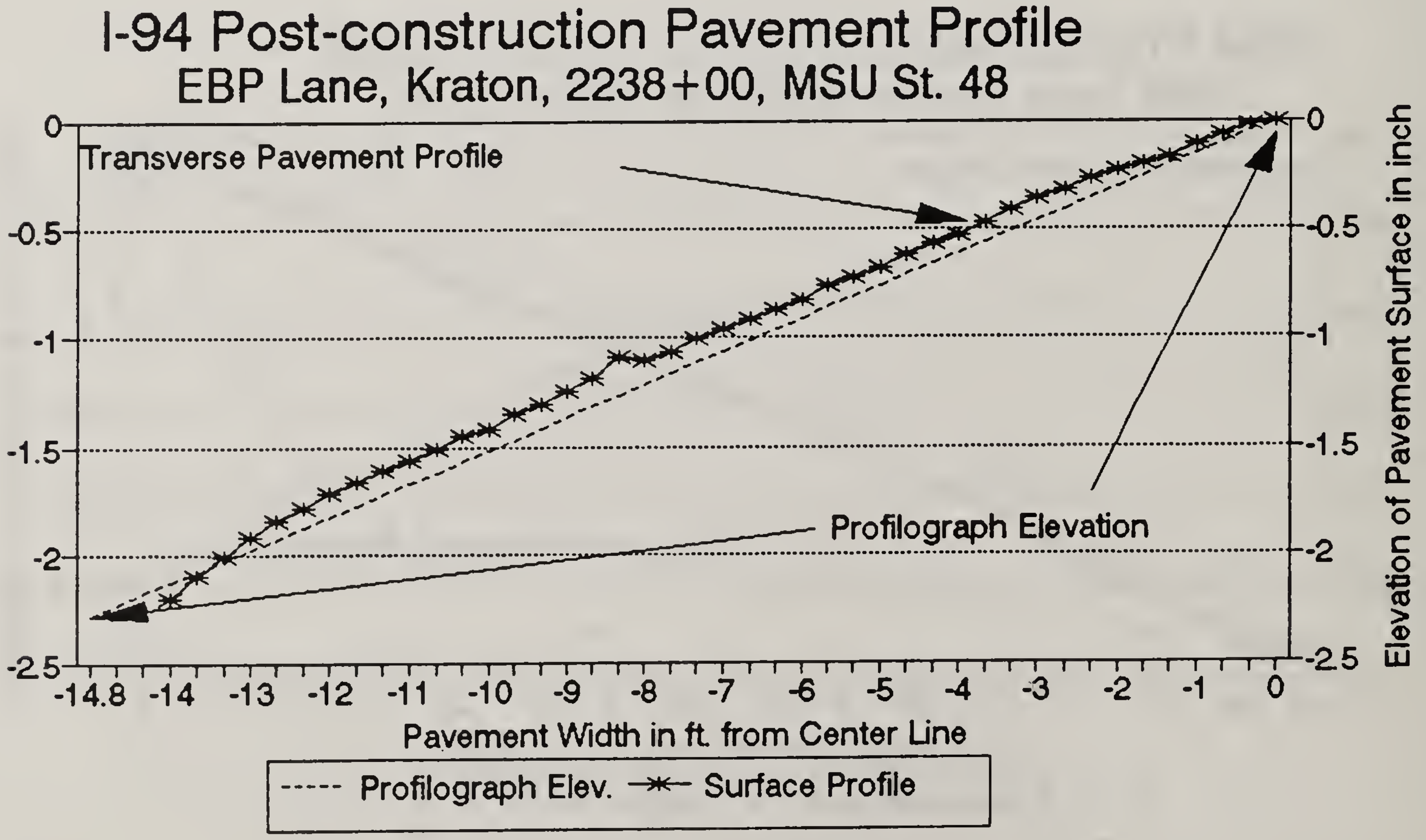


Fig. 23D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



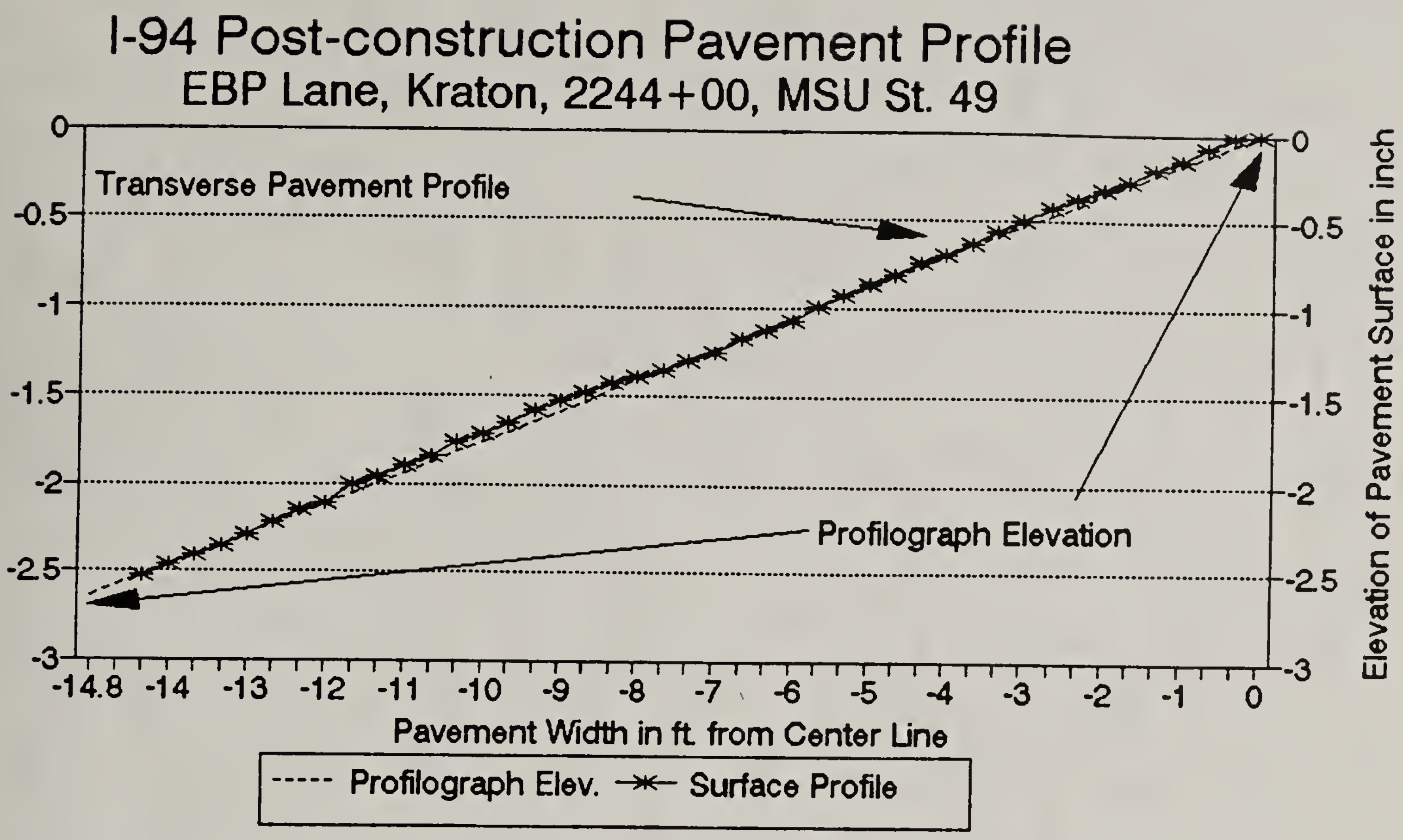
I-94 Post-construction Pavement Profile
EBP Lane, Kraton, 2232+00, MSU St. 47

Note: East Bound Passing (EBP) Lane, Kraton Modified Binder



I-94 Post-construction Pavement Profile
EBP Lane, Kraton, 2238+00, MSU St. 48

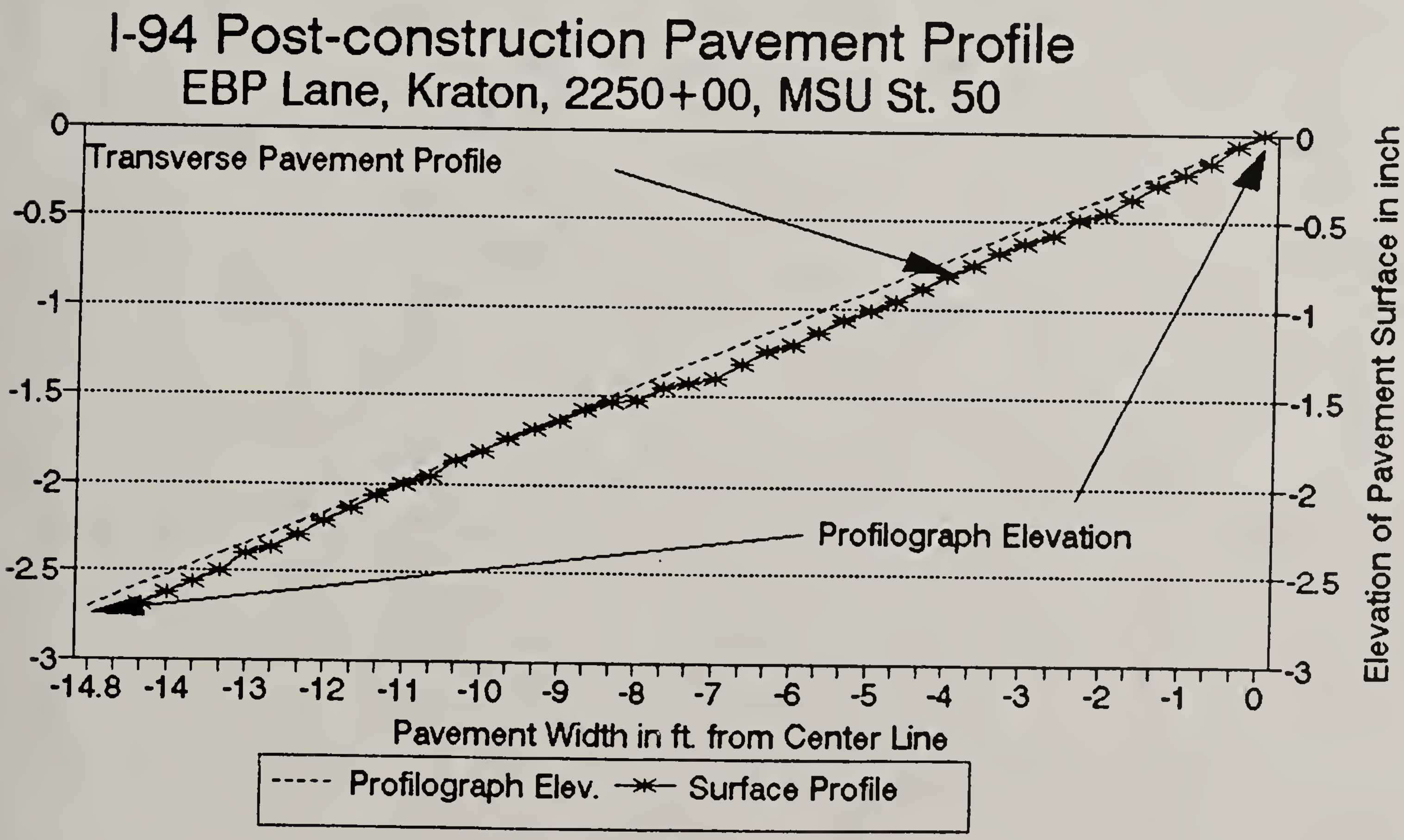
Fig. 24D. Post-construction Profile and Elevation, Center Line of Pavement as Origin



I-94 Post-construction Pavement Profile

EBP Lane, Kraton, 2244+00, MSU St. 49

Note: East Bound Passing (EBP) Lane, Kraton Modified Binder



I-94 Post-construction Pavement Profile

EBP Lane, Kraton, 2250+00, MSU St. 50

Fig. 25D. Post-construction Profile and Elevation, Center Line of Pavement as Origin

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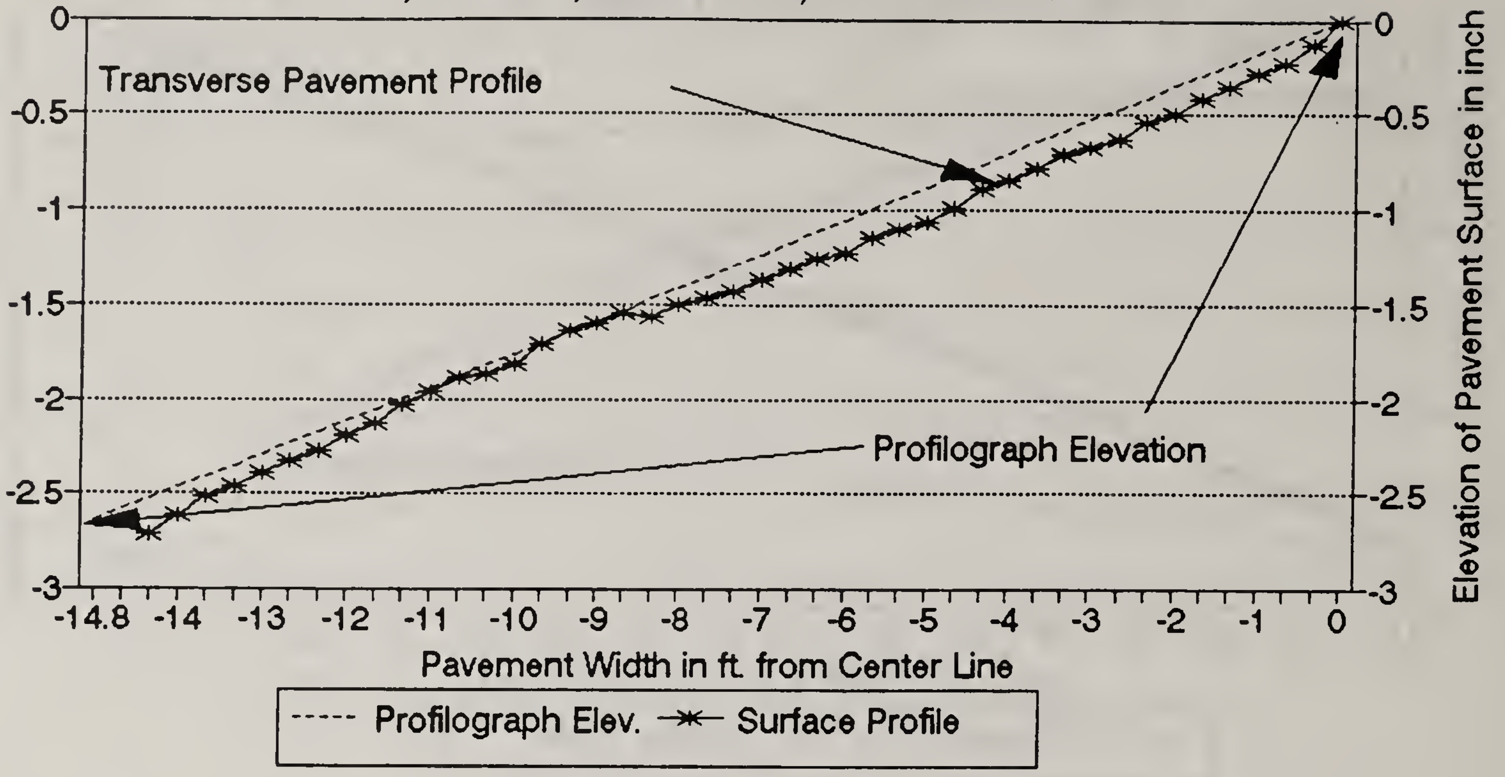
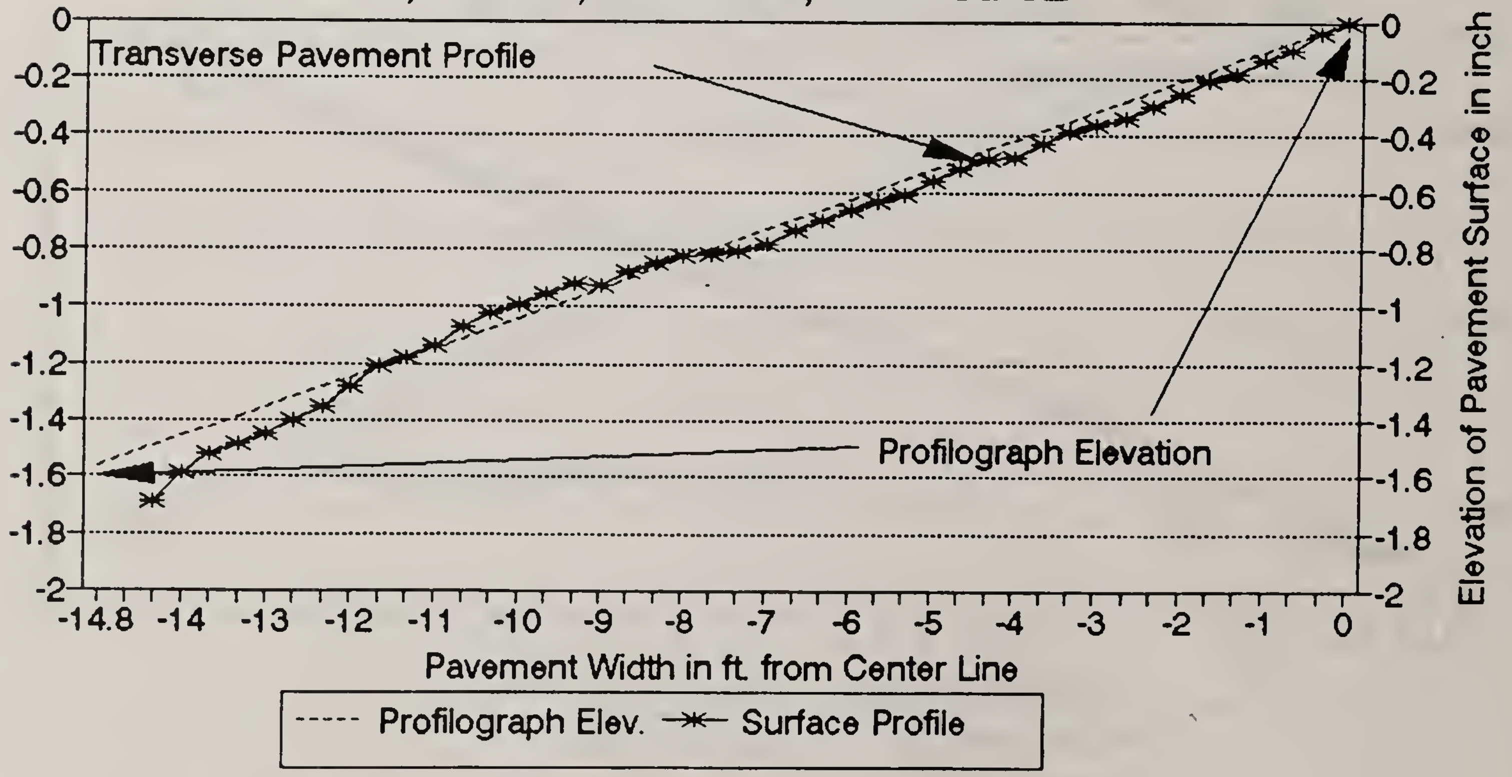


I-94 Post-construction Pavement Profile
EBP Lane, Kraton, 2254+00, MSU St. 51

Note: East Bound Passing (EBP) Lane, Kraton Modified Binder



I-94 Post-construction Pavement Profile
EBP Lane, Kraton, 2260+00, MSU St. 52

Fig. 26D. Post-construction Profile and Elevation, Center Line of Pavement as Origin